STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF EQUIPMENT
MAINTENANCE
AND DEVELOPMENT

86-10

Final Report

CRASH TEST OF CONE TRUCK FOR OPERATOR SAFETY

Federal Research Grant No. F82EQ07

86-10

#76

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF EQUIPMENT MAINTENANCE AND DEVELOPMENT

CRASH TEST OF CONE TRUCK FOR OPERATOR SAFETY

Study Made for....................Division of Equipment Maintenance and Development

Study Made By....................Division of Equipment Maintenance and Development

Under the Supervision of.........John Marlow, P.E.

Principal Investigator...........Calvin Schiefferly

Report Prepared by..............Calvin Schiefferly

Consultant.......................Roger Stoughton, P.E.

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This study was done in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

With the thousands of miles of interstate and state highways in our nation, safe and efficient methods for maintenance of highways is crucial to our national transportation system.

The cone truck has become a valuable tool in achieving safety and efficiency in highway maintenance operations.

The objective of this research was to evaluate and improve, if necessary, the crash worthiness of the cone truck.

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Cone, traffic delineator, lane closure, cone truck, crash test	No restrictions

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NOTICE

The contents of this report reflects the views of the researchers who have endeavored to present accurate data and draw conclusions in a clear and objective manner.

The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quanity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40	millimetres (mm)
		.02540	metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2)	.09290	square metres (m^2)
	acres	.4047	hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour(mph)	.4470	metres per second (m/s)
	feet per second(fps)	.3048	metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity(G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^2)
Force	pounds (lbs)	4.448	newtons(N)
	kips (1000 lbs)	4448	newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds(ft-lb)	1.356	joules (J)
	foot-kips (ft-k)	1356	joules (J)
Bending Moment or Torque	inch-pounds(ft-lbs)	.1130	newton-metres (Nm)
	foot-pounds(ft-lbs)	1.356	newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

CRASH TESTS OF CONE TRUCK FOR OPERATOR SAFETY

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Caltrans (California Department of Transportation) Division of Maintenance uses a standard traffic cone for all short term lane closures to perform various highway maintenance work. The traffic cone used is 28-inches tall, 14-inches square base, fluorescent colored, and weights 10 pounds. (1)* The benefits of using a traffic cone are numerous, i.e., storing, handling, stability, public awareness of a traffic delineation device, etc.

Over the past 15 to 20 years, traffic cones have been set and retrieved from the roadway by workers on foot, cone chutes, and mechanical devices. As a result of inefficient and troublesome methods the cone truck evolved. The cone truck positions the cone setter person at a location where the operation of setting and retrieving cones can be accomplished at a reasonable speed of 15 to 20 mph.

Caltrans presently has 180 cone trucks in service. Each day Caltrans workers establish and remove an average of 189 lane closures.

Each lane closure averages 1.2 miles requiring 90 cones. The cone truck has a capacity of 250 cones. The cone truck design has also been utilized by several western states and private construction companies.

Caltrans also utilizes a cone setting device that mounts to the front of a truck. This device positions the cone setter person in a basket stand-up type unit with a rotating rack of cones adjacent to her/him. These units are slowly being replaced in areas where frequent lane closures are required. For this reason they will not be addressed in this report.

In contrast to Caltrans high frequency of daily temporary lane closures, highway maintenance lane closures in most other states are established for periods of days and weeks. Low traffic volumes make it unnecessary for most other states to have any degree of sophistication in equipment or methods to establish and remove temporary lane closures. Cone devices are either "walked" out or placed by a combination of a worker standing in the back of a slow moving truck handing devices to a worker(s) on foot. Even Texas, which has some high volume and high speed freeways in the Dallas and Houston areas, sets/retrieves cones using the latter method. Another method sometimes used by other states is a worker who sits on the tailgate of a slow moving truck and sets cones onto the pavement as the truck moves along.

* Numbers in parenthesis refer to a reference list at the end of this report.

1.2 Objectives

Caltrans has expanded the use of cone trucks, as the result of an inter-department study (2) conducted in 1982. With additional cone trucks in operation by Caltrans, other states and private construction companies, crash testing of the cone truck body is imperative to check its structural integrity.

The objective of this research was to confirm or to improve the cone truck body design by actual crash tests results.

2. General Discussion

Caltrans designed and put into service the first cone trucks in 1977. Caltrans' process for procurement of equipment entails a set of design drawings or specifications that is distributed among an established list of qualified bidders. The cone truck body is purchased using a set of design drawings (see figures 2 through 13), and the cab and chassis is purchased using a specification (5).

Since the first cone truck introduction the basic configuration has not changed. Components have been added to meet additional operational requirements for lane closures. Major components that have been added are sequential arrowboard signs, auxiliary generators, and rear opening windows (for communication).

In addition to maintenance work the cone truck has become an emergency type vehicle used for lane closures resulting from hazardous spills, floods, major accidents, and major attractions requiring traffic control.

Operational procedures for traffic control utilizing the cone truck are covered in the Caltrans Maintenance Manual (3). Included in the Maintenance Manual are instructions for placement locations of the various traffic control devices, such as signs, arrowboards, barrier trucks, and cones. Caltrans requires the use of shadow trucks for all slow moving maintenance operations. This requirement includes the use of the cone truck. Whenever the cone truck is setting or retrieving traffic cones, a larger truck with an attenuator is required to provide a barrier between the traffic and the cone truck. (This is a change in operational procedures that occurred after, but not as a result of this research.) After the lane closure is established, the shadow truck becomes the barrier vehicle to protect the work zone within the lane closure. The cone truck is parked ahead (downstream) of the work zone and during a full-day operation, will loop around

and reset any cones that become displaced.

From the safety point of view, the cone truck has an excellent record and offers several benefits over other methods of cone setting. In a cone truck the cone setter/retriever (person) is belted into a firmly anchored high backed seat within the body of the truck. There has been one documented accident with an operator in the cone setter/retriever position.

The accident happened on October 29, 1980, when a motorist impacted the right rear of a cone truck at approximately 60 miles per hour. The motorist, driving a 1/2-ton pickup, was forced into the cone truck by another vehicle. The maintenance worker driving the cone truck saw the errant motorist coming towards him and accelerated to get out of the way, but the cone truck was impacted in the right rear quarter panel. There was no injury to the cone setter/retriever and damage to the cone truck amounted to $550.

Additional safety benefits of the cone truck include:

- o Loading/unloading of cones to/from the truck is not required thus eliminating back injuries. (The cone truck stays loaded with cones.)

- o The average lane closure is 1.2 miles, at the speed the cone truck can operate (15 to 20 mph) the lane closure is installed or retrieved in 3 to 5 minutes.

  This has numerous benefits, traffic, safety, labor savings, operations overall safety, and exposure of crews to traffic.

3. Conclusions

The following conclusions were based on the results of three 45 mph and one 60 mph passenger car impact tests into the rear and side (25^{o} angle) of the cone truck. Since the cone truck is of primary concern in this research, the impacting passenger car will not be considered in the following. Two appraisal factors used to judge the results were structural integrity (cone truck body) and occupant risk (cone setter person).

3.1 Structural Integrity

Although all four tests were severe, angle of impact and speed, there was no structural damage to the cone setter compartment of the cone truck. In test #421 (rear impact), the cone body sheet metal behind the rear axle absorbed the impact leaving the front half of the cone body damage free.

In tests 422, 423, and 424 (all at 25° angle), the impact was centered on the cone setters compartment. In all three tests, the compartment was left free of any structural damage.

3.2 Occupant Risk

In all tests, the accelerations for the cone truck longitudinal were at or below 10.8 g's indicating they were below 12 g's (limit in Research Circular No. 191) (4).

In test 422 (first 25° angle test), the front corner of the impacting car's hood rode over the rail of the cone setter compartment. This allowed the corner of the hood to penetrate and damage the dummy that was in the cone setters position. In the following two tests (423 and 424), an attachment (see Figure 1) was fabricated and installed as shown. Neither in test 423 nor 424 was it possible to repeat the circumstances that resulted in the hood penetrating the cone setter compartment of test 422. At re-evaluating test 422, it was concluded that impacting the cone truck at an angle produced an opening for penetration at 30 inches above ground level. Also as the impacting angle increases, the more likely the impacting vehicle's bumper system will prevent the hood from reaching into the compartment.

3.3 Conclusions, General

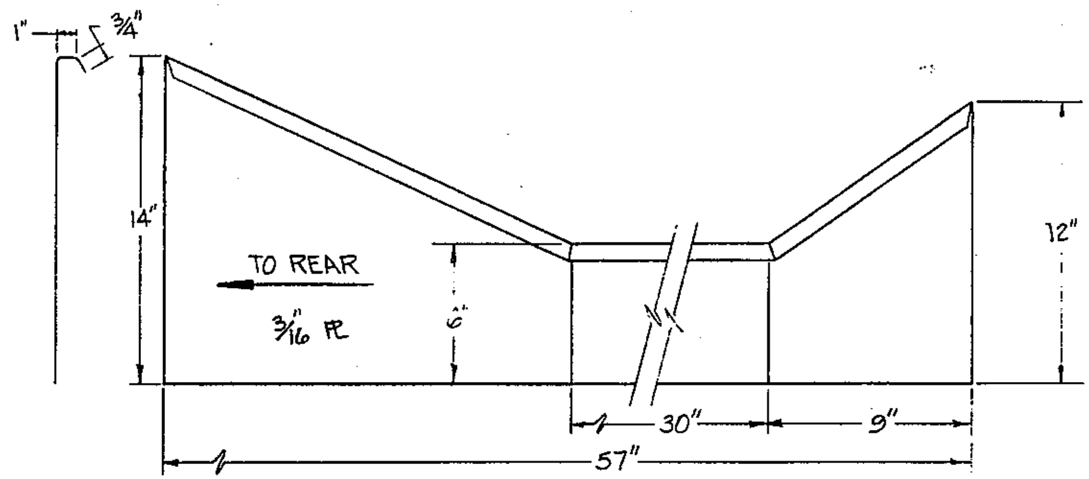
The cone truck body performed well at providing a safe work location. It is possible for an impacting vehicle's sheet metal to penetrate over the cone setters compartment rail when impacted at an angle of 20 to 30 degrees. However, with new operation procedures, other makes of cars and smaller cars, occurrence of this happening is greatly reduced.

4. Recommendations

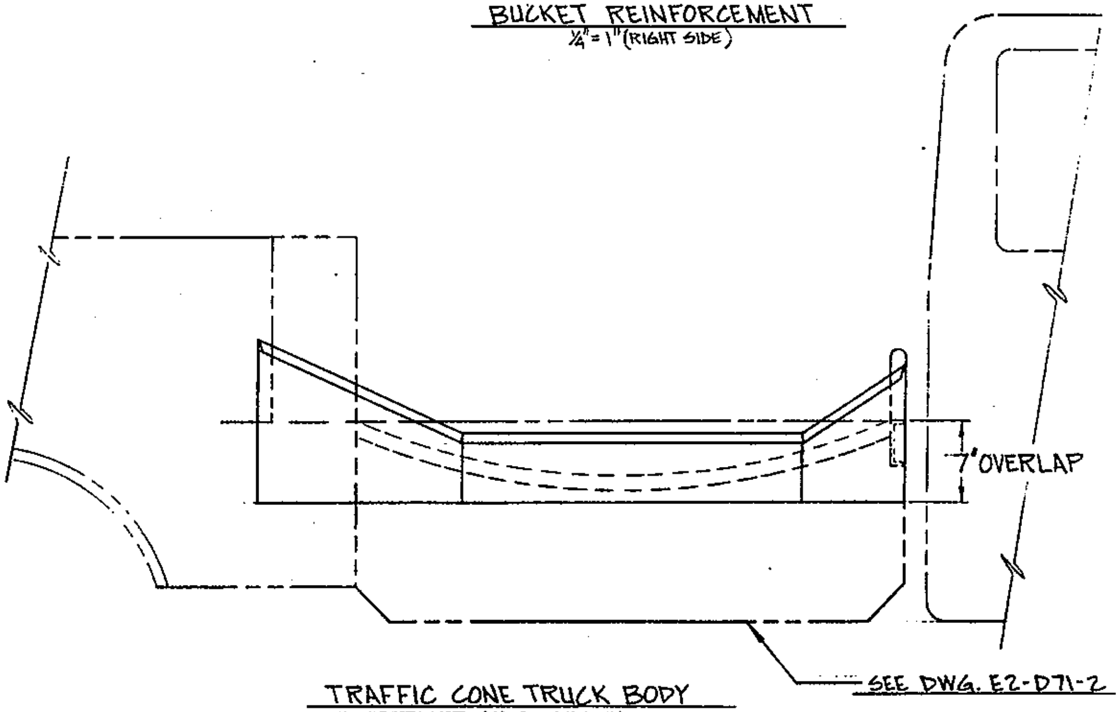
1. Field evaluations of latest operational procedures involving the cone truck should be done. In evaluating the procedures, particular emphasis should be placed on chances of an angle impact when cone setter person is in cone body.

2. The attachment used in test 423 and 424 should be installed on a limited number of cone trucks for field evaluation. Attachment could result in hampering cone setting/retrieving process, entrance into body, etc.

3. If attachment hampers operation of cone truck, an alternate solution should be devised and field tested. If attachment does not hamper operation, all cone trucks should be retrofitted.



BUCKET REINFORCEMENT
1/4" = 1" (RIGHT SIDE)



TRAFFIC CONE TRUCK BODY
RIGHT SIDE - SHOWN
LEFT SIDE - OPPOSITE
1/8" = 1"

ITEM	DATE	REVISION	BY

UNLESS OTHERWISE SPECIFIED. ALL WELDS TO BE CONTINUOUS. SIZE OF ALL WELDS TO BE AT LEAST HALF THE THICKNESS OF THE THINNER OF THE ADJACENT METALS.

TOLERANCE—UNLESS OTHERWISE SPECIFIED.
DECIMAL ± "
FRACTIONAL ± 1/32
ANGULAR ± 1°

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BUCKET SIDE REINFORCEMENT FOR TRAFFIC CONE TRUCK BODY

SCALE AS NOTED	DATE 6-24-86	
DRAWN J RIME	FILE	
CHECKED	APPROVED	SHEET __ OF __ SHEETS

Figure 1

5. Implementation

Caltrans, Division of Equipment Maintenance and Development has a process for implementing field modifications. The process used is referred to as a Technical Service Bulletin. In this case, should the cone truck attachment be accepted, by actual field test, an equal number of attachments for all cone trucks would be manufactured and disbursed to all field shops with a Technical Bulletin for field installation.

6. TECHNICAL DISCUSSION

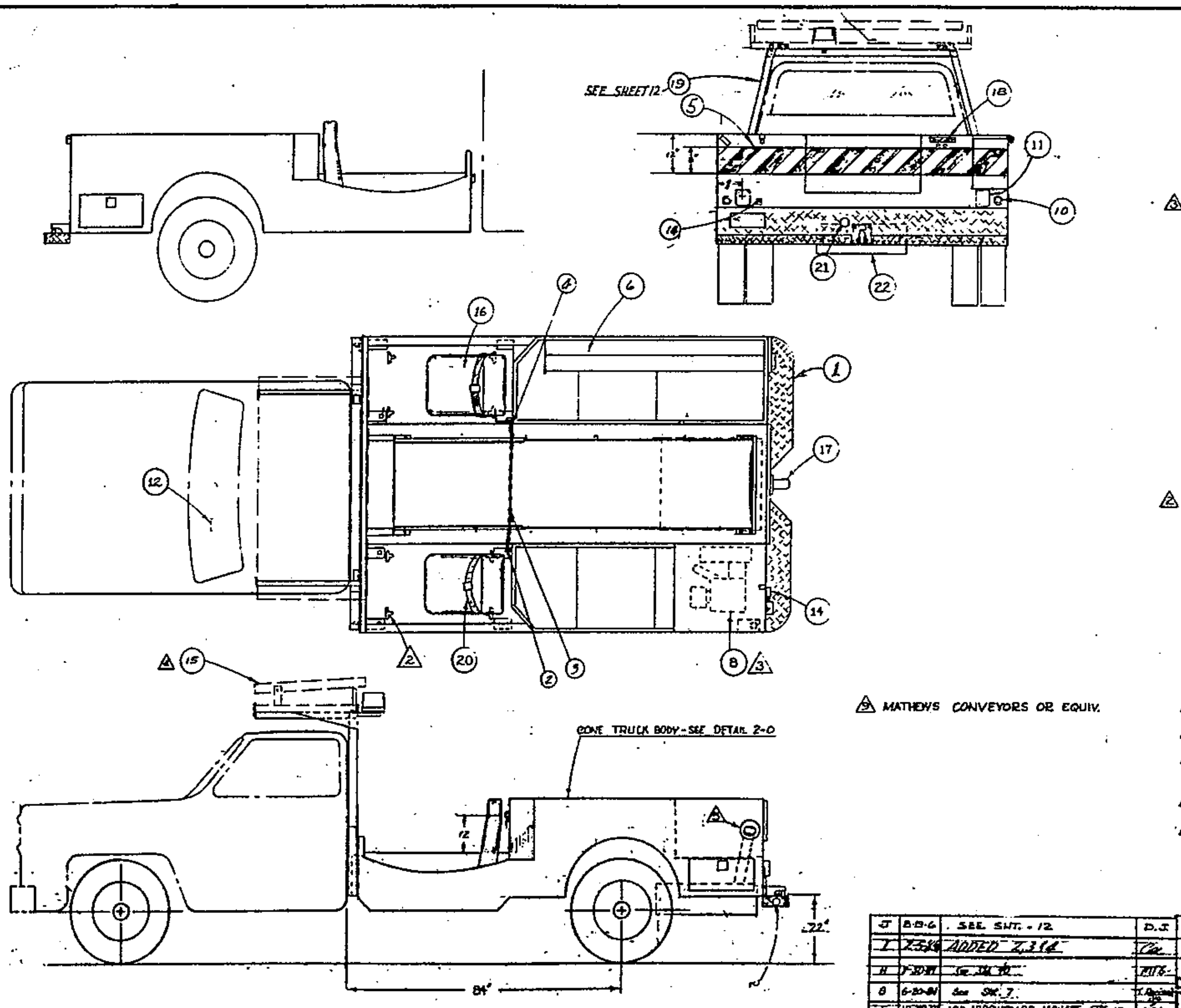
6.1 TEST CONDITIONS

6.1.1 Test Facility

All cone truck impact tests conducted at Caltrans Dynamic Test Facility in Bryte, California (near Sacramento). The test took place on flat, asphalt, concrete, paved surfaces. The weather was clear and mild for all tests.

6.1.2 Cone Truck Design

The cone truck body is designed to be mounted on a standard one-ton (10,000 to 11,000 gross vehicle weight GVW) chassis with a cab-to-axle (CA) dimensions of 84 inches and frame width of 34 inches. This longer CA dimension allows the space for the operator's position to be located between the back of the cab and the rear axle. The operator's compartment is fabricated of 1/4"-steel plate with a 1-1/2-inch pipe railing. A conveyor 26 inches wide, full length of the body is provided to move cones to within reach of the operator. The conveyor is powered by a bi-directional 12-volt DC motor through a 60 to 1 reduction gearbox. There are foot control switches in each operator's compartment to control the movement of the conveyor. At each side of the conveyor and to the rear of the operator's positions there are storage compartments. Storage compartments are used for extra cones, signs, sign tubes, sign tripods, sandbags (to stabilize tripods), batteries/lights (for night operations) and tools. As an option, an 8-horsepower gasoline 12-volt generator is installed in the left compartment at the rear. The generator is used to power the sequential arrowboard while the truck is parked for extended periods. Drawings used for fabrication and mounting of the body are shown in figures 2 through 13. The specification used for purchasing the truck is listed in the References (5).



DET	QTY	MATERIALS
1	1	88" WIDE STD. BUMPER SEE DWG# E2-D120-1&2.
2	2	EYEBOLT-5/16 W/DOUBLE NUT & FLAT WSH
3	1	CHAIN-GENERAL PURPOSE 3/16 ZINC PLATED
4	2	DOUBLE ENDED BOLT SNAP 3/8 ZINC PLATED
5	:	3M REFLECTIVE TAPE
6	1	GTUBE SIGN HOLDER W/DOOR E1-D126-1
8	1	GENERATOR, AUX POWER PLANT HQ# 18-1149
10	4	CLEARANCE LAMP - TRUK-LITE 30200R - HQ 37M1462 WITH 27A1280 KIT
11	2	TAIL LIGHT OEM STOCK
12	1	DASH PANEL DWG# E1-B86-1 HQ# 05-3022
14	1	BACKUP ALARM BULLARD MPA II HQ 20-1654
15	1	SEQUENTIAL PASS SIGN - TRAFFIC CONTROL SYSTEM OR EQUIVALENT HQ# 20-1756
16	2	BUCKET SEAT - PADDED HIGH BACK
17	1	HITCH - HOLLAND 7-60-4L HQ 56-1002
18	1	IDENTIFICAT PLAQUE - PLASTIC -
19	1	SIGN MOUNTING-FRAME MOUNT DWG E2-D71-12
20	2	SEAT BELT SUPERIOR 46-3230B HQ# 20-1006
21	1	7 PIN CONNECTOR POLLAK 77-5 HQ# 09M1265
22	1	GAS TANK - 32 GALLON

GEN. NOTES

1. ALL WELDS AS SPECIFIED IN TITLE BLOCK.
2. SEAT BELT ANCHOR SEE DWG# E2-D71-5
3. ROUTE AUXILIARY POWER EXHAUST THROUGH BOTTOM OF ENGINE COMPARTMENT
4. INSTALL SIGN CONTROL PANEL UNDER DASH
5. FUEL FILLER

J	8-8-86	SEE SHT. - 12	D.J.
I	7-3-86	ADDED 2, 3, 4	
H			
G	6-20-84	See SH. 7	
F		ADD ARROWBOARD MOUNT. SH. 12	
E		REDESIGNED & REDRAWN	
D	3/17/83	CONVEYOR DRIVE CHANGED ON SHT. 2	MG
C	3/11/83	CONVEYOR DRIVE CHANGED ON SHT. 3 - ADD SHT 10	
C	3/4/83	WIRING CHART ON SHT. 7, SHT 9 ADDED	MG

C	10-25-85	REDESIGN - ADD SIGN MOUNT FRAME	MG
B	9-28-81	REDESIGN & REDRAWN	TB
A	8/22/80	RENUMBER	RF

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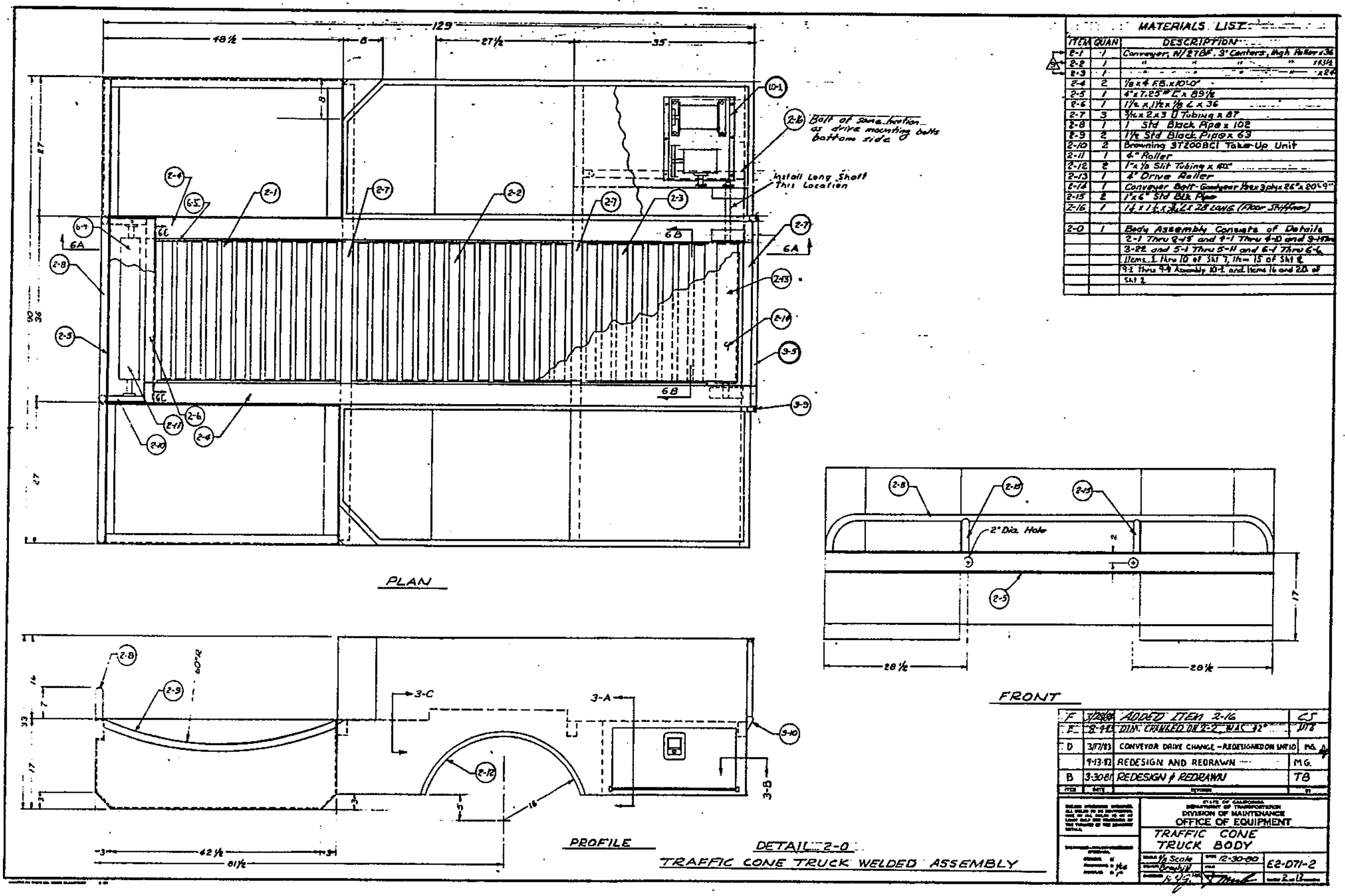
TRAFFIC CONE TRUCK BODY

6/24/80

E2-D71-1


MATERIALS LIST
ITEM QUAN DESCRIPTION
2-1 1 Conveyor, H/27BF, 9' Centers, High Roller x36
2-2 1 " " " " x13½
2-3 1 " " " " x24
2-4 2 ⅛x4 F.B.x10'-0"
2-5 1 4"x7.25# [x 89½
2-6 1 1½ x 1½ x ⅛ ∠ x 36
2-7 3 3/16 x 2x3 ▯ Tubing x 87
2-8 1 1 Std Black Pipe x 102
2-9 2 1½ Std Black Pipe x 63
2-10 2 Browning 9T200BC1 Take-Up Unit
2-11 1 4" Roller
2-12 2 1"x ⅛ Slit Tubing x 40"
2-13 1 4" Drive Roller
2-14 1 Conveyor Belt-Goodyear 3 ply x 26" x 20'-9"
2-15 2 1"x6" Std Blk Pipe
2-16 1 1¼ x 1¼ x ⅛ ∠ x 28 LONG (Floor Stiffener)
2-0 1 Body Assembly Consists of Details 2-1 Thru 2-15 and 4-1 Thru 4-10 and 3-1 Thru 3-22 and 5-1 Thru 5-11 and 6-1 Thru 6-6, Items 1 thru 10 of Sht 7, Item 15 of Sht 8, 9-1 thru 9-9 Assembly 10-1 and Items 16 and 20 of Sht 1
Bolt at same location as drive mounting bolts bottom side
Install Long Shaft This Location
2" Dia. Hole
PLAN
FRONT
PROFILE
DETAIL 2-0
TRAFFIC CONE TRUCK WELDED ASSEMBLY
F 3/29/88 ADDED ITEM 2-16
E DIM. CHANGED ON 2-2, WAS 12"
D 3/17/83 CONVEYOR DRIVE CHANGE - REDESIGNED ON SHT 10
9-13-82 REDESIGN AND REDRAWN
B 3-30-81 REDESIGN & REDRAWN
STATE OF CALIFORNIA
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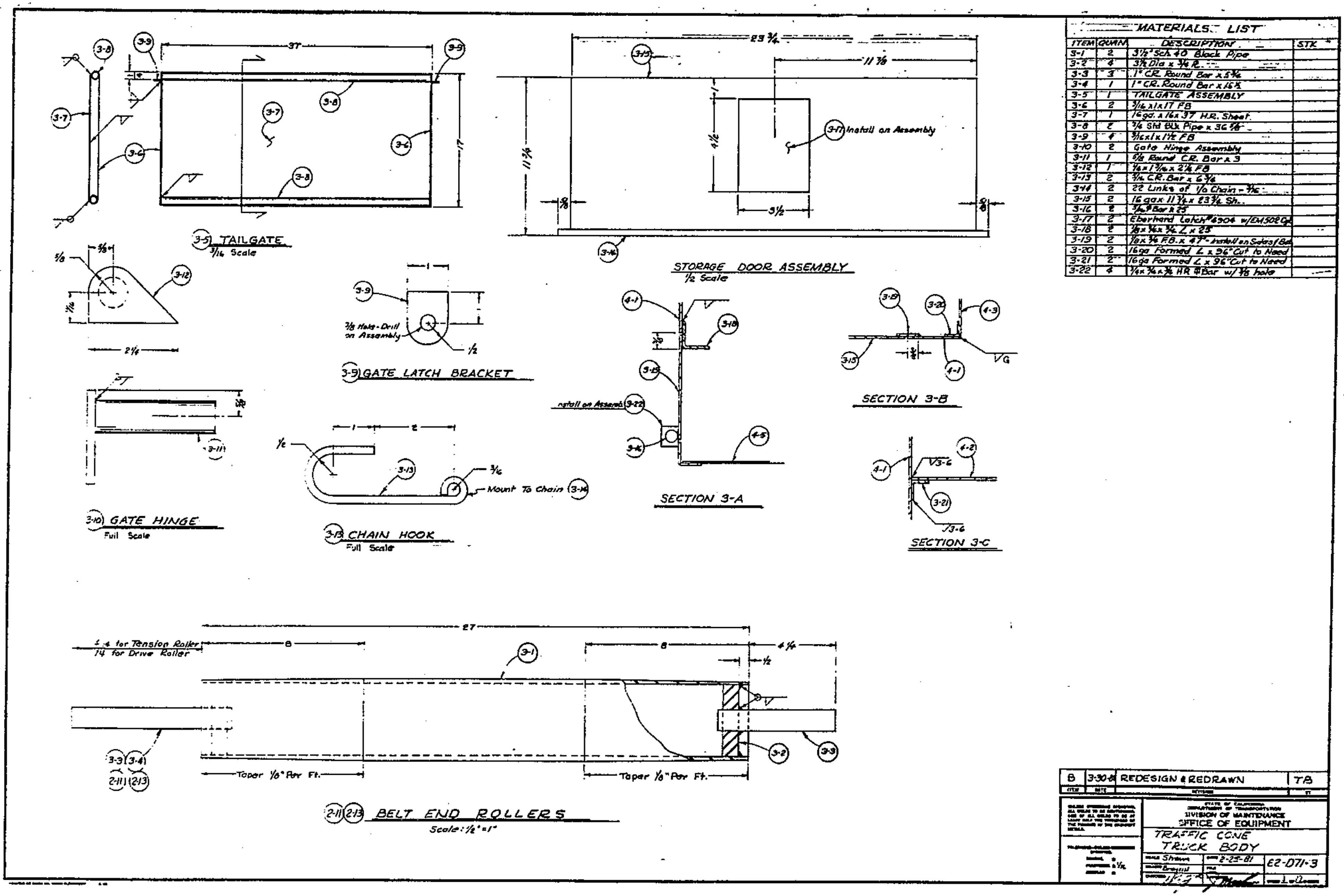
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
TRAFFIC CONE TRUCK BODY
⅛ Scale
12-30-80
E2-D71-2

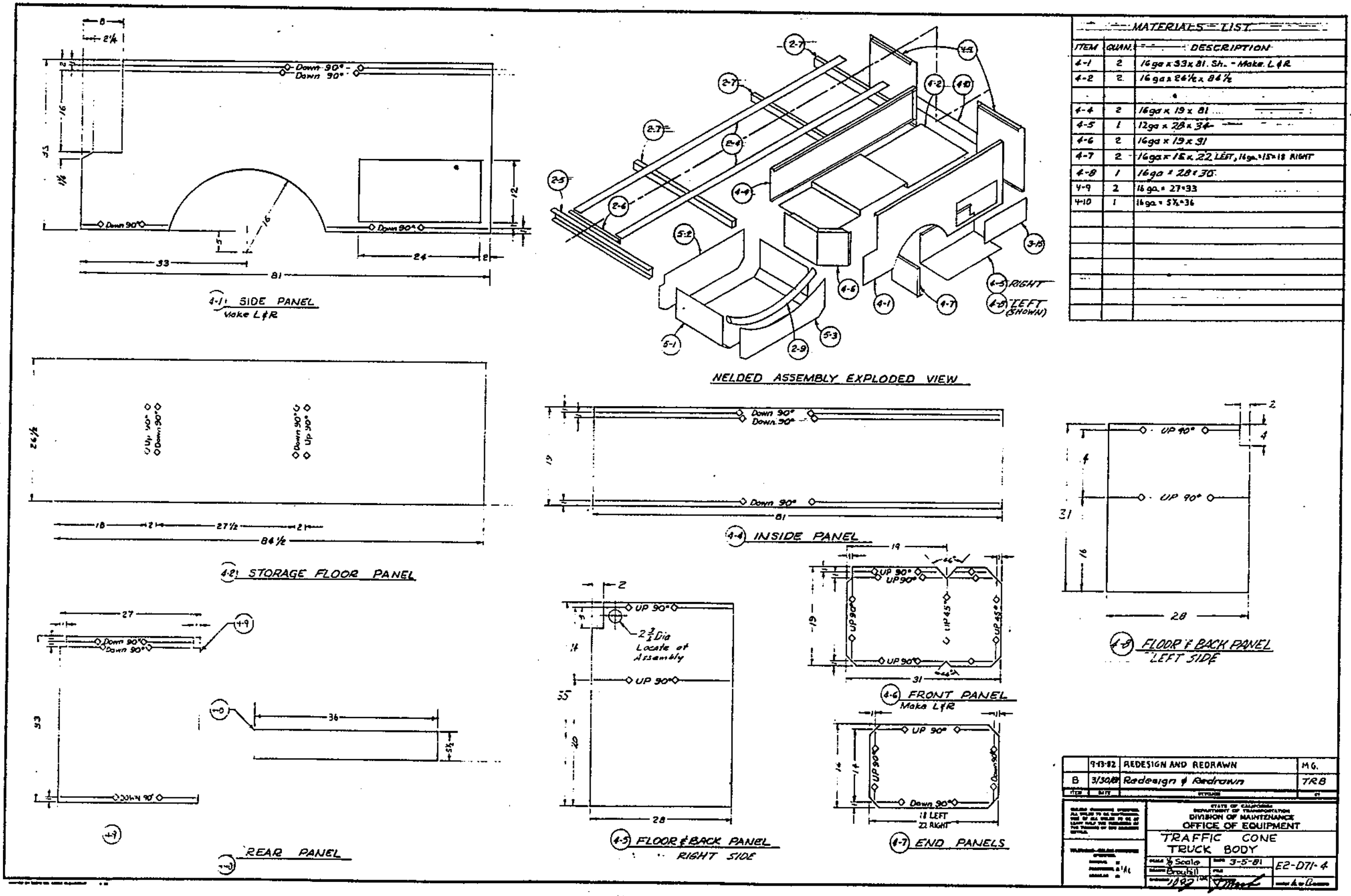
Figure 3



MATERIALS LIST

ITEM	QUAN	DESCRIPTION	STK
3-1	2	3½" Sch 40 Black Pipe	
3-2	4	3⅞ Dia x ¼ R.	
3-3	3	1" CR. Round Bar x 5¾	
3-4	1	1" CR. Round Bar x 16½	
3-5	1	TAILGATE ASSEMBLY	
3-6	2	3/16 x 1 x 17 FB	
3-7	1	16 ga. x 16 x 37 H.R. Sheet	
3-8	2	¾ Std Blk Pipe x 36⅝	
3-9	4	3/16 x 1 x 1½ FB	
3-10	2	Gate Hinge Assembly	
3-11	1	⅝ Round CR. Bar x 3	
3-12	1	¼ x 1 7/16 x 2¼ FB	
3-13	2	3/16 CR. Bar x 6¾	
3-14	2	22 Links of 1/0 Chain - 3/16	
3-15	2	16 ga x 11¼ x 23¾ Sh.	
3-16	2	3/16 # Bar x 25	
3-17	2	Eberhard Latch #4904 w/EH502 G	
3-18	2	⅛ x ¾ x ¾ ∠ x 25	
3-19	2	⅛ x ¾ F.B. x 47" - Install on Sides/Bot	
3-20	2	16 ga Formed ∠ x 96" Cut to Need	
3-21	2	16 ga Formed ∠ x 96" Cut to Need	
3-22	4	¼ x ¾ x ¾ HR # Bar w/ ⅜ hole	

Figure 4


MATERIALS LIST
ITEM QUAN. DESCRIPTION
4-1 2 16 ga x 33 x 81 Sh. - Make L & R
4-2 2 16 ga x 24½ x 84½
4-4 2 16 ga x 19 x 81
4-5 1 12 ga x 28 x 34
4-6 2 16 ga x 19 x 31
4-7 2 16 ga x 18 x 22 LEFT, 16 ga x 15 x 18 RIGHT
4-8 1 16 ga x 28 x 30
4-9 2 16 ga x 27 x 33
4-10 1 16 ga x 5½ x 36
4-1 SIDE PANEL
Make L & R
WELDED ASSEMBLY EXPLODED VIEW
4-2 STORAGE FLOOR PANEL
4-4 INSIDE PANEL
4-8 FLOOR & BACK PANEL
LEFT SIDE
4-5 FLOOR & BACK PANEL
RIGHT SIDE
4-6 FRONT PANEL
Make L & R
4-7 END PANELS
REAR PANEL
9-13-82 REDESIGN AND REDRAWN MG.
B 3/30/81 Redesign & Redrawn TRB
STATE OF CALIFORNIA
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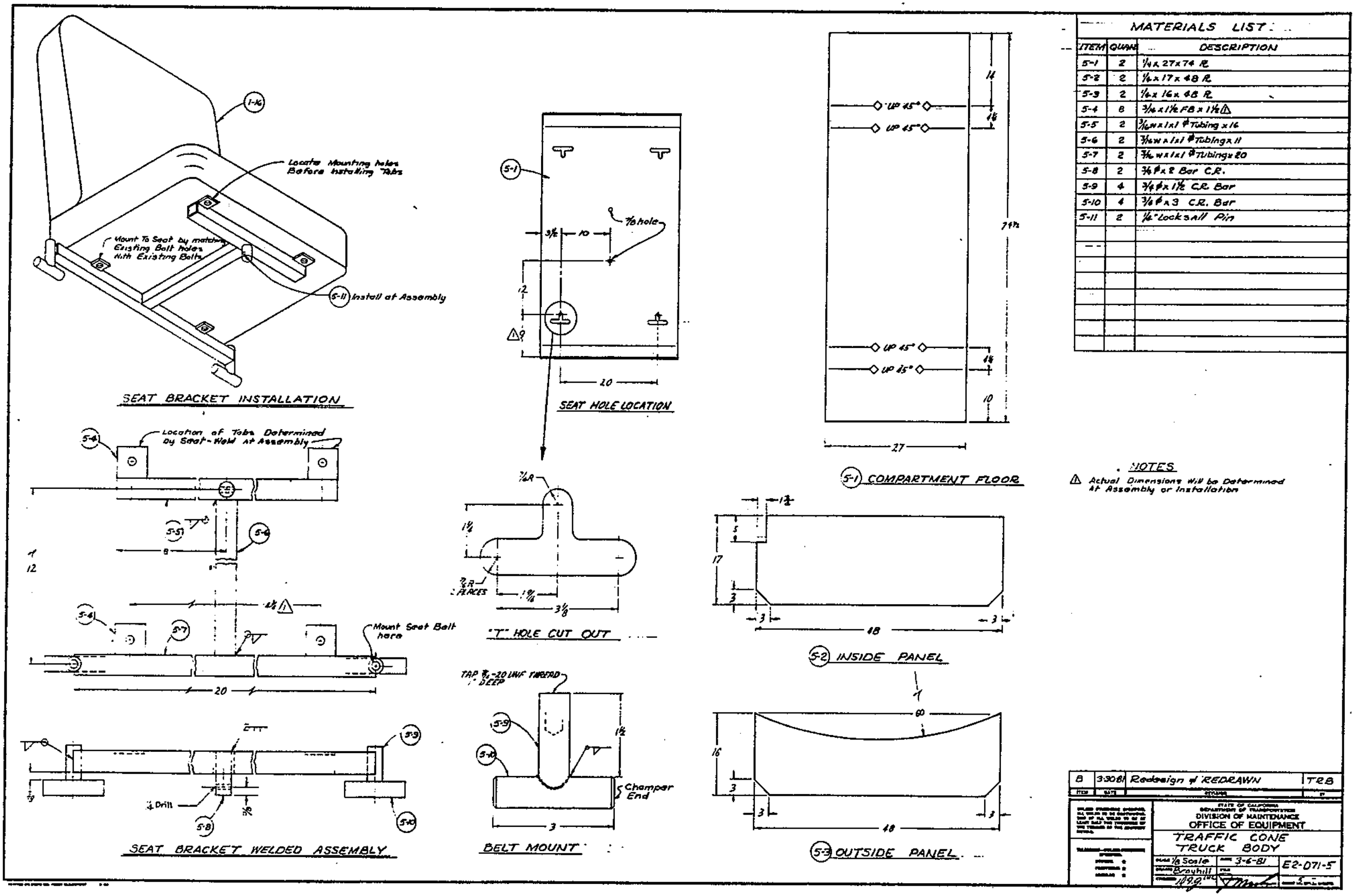
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
TRAFFIC CONE
TRUCK BODY
½ Scale
3-5-81
E2-D71-4

Figure 5



ITEM	QUAN	DESCRIPTION
5-1	2	1/4 x 27 x 74 R
5-2	2	1/6 x 17 x 48 R
5-3	2	1/6 x 16 x 48 R
5-4	8	3/16 x 1 1/2 FB x 1 1/2 △
5-5	2	3/16 w x 1 x 1 # Tubing x 16
5-6	2	3/16 w x 1 x 1 # Tubing x 11
5-7	2	3/16 w x 1 x 1 # Tubing x 20
5-8	2	3/8 # x 2 Bar C.R.
5-9	4	3/4 # x 1 1/2 C.R. Bar
5-10	4	3/8 # x 3 C.R. Bar
5-11	2	1/4" Lock-all Pin

Figure 6

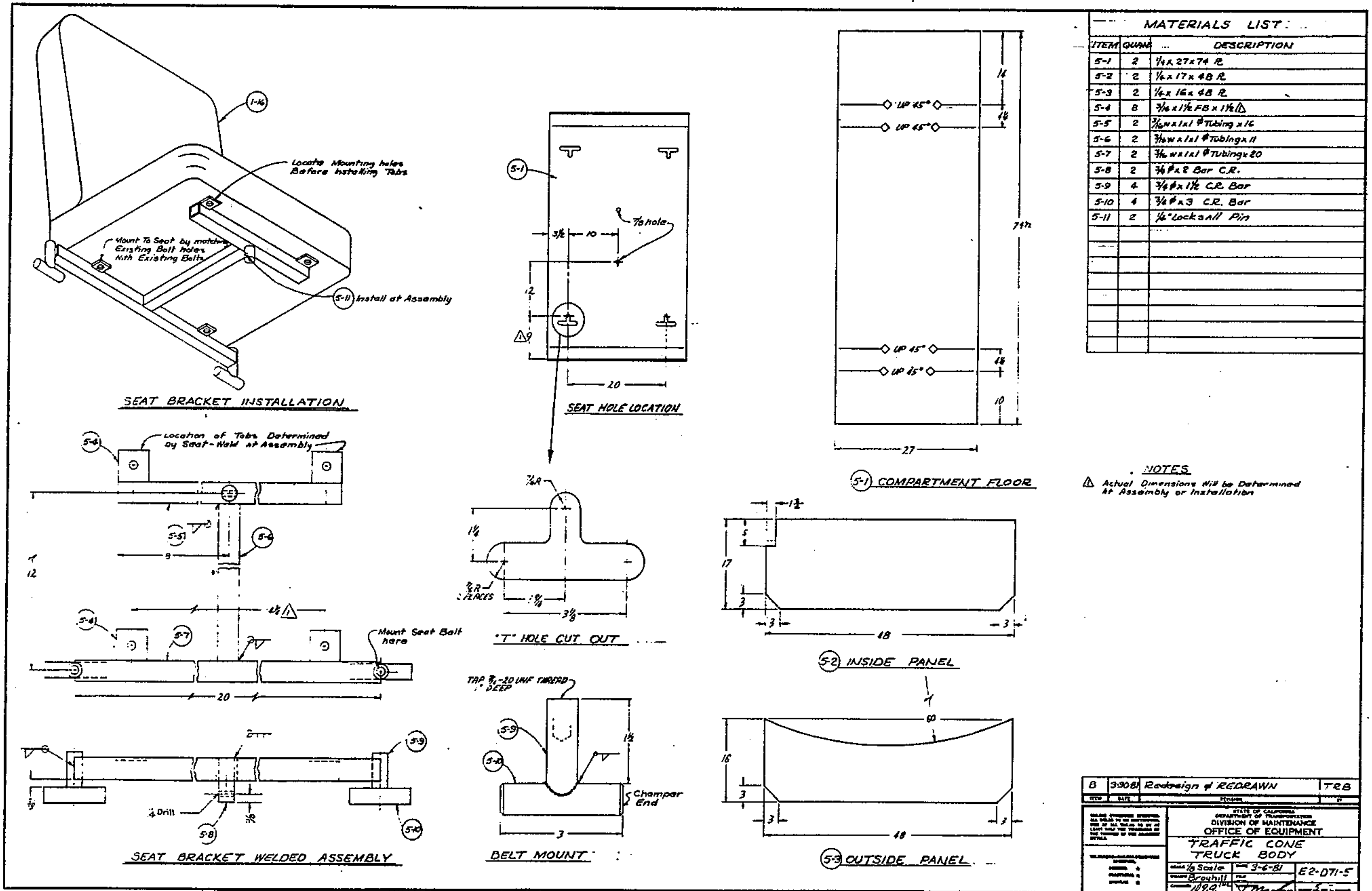

MATERIALS LIST
ITEM | QUAN | DESCRIPTION
5-1 | 2 | 1/4 x 27 x 74 PL
5-2 | 2 | 1/6 x 17 x 48 PL
5-3 | 2 | 1/6 x 16 x 48 PL
5-4 | 8 | 3/16 x 1 1/2 FB x 1 1/2
5-5 | 2 | 3/16 w x 1 x 1 Tubing x 16
5-6 | 2 | 3/16 w x 1 x 1 Tubing x 11
5-7 | 2 | 3/16 w x 1 x 1 Tubing x 20
5-8 | 2 | 3/8 x 2 Bar C.R.
5-9 | 4 | 3/4 x 1 1/2 C.R. Bar
5-10 | 4 | 3/4 x 3 C.R. Bar
5-11 | 2 | 1/4" Locksall Pin
NOTES
Actual Dimensions Will be Determined At Assembly or Installation
Locate Mounting holes Before Installing Tabs
Mount To Seat by matching Existing Bolt holes With Existing Bolts
Install at Assembly
SEAT BRACKET INSTALLATION
7/8 hole
SEAT HOLE LOCATION
COMPARTMENT FLOOR
UP 45°
Location of Tabs Determined by Seat-Weld at Assembly
Mount Seat Belt here
"T" HOLE CUT OUT
INSIDE PANEL
TAP 7/16-20 UNF THREAD 1" DEEP
Chamfer End
BELT MOUNT
OUTSIDE PANEL
1/4 Drill
SEAT BRACKET WELDED ASSEMBLY
Redesign & REDRAWN
STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
TRAFFIC CONE TRUCK BODY
1/8 Scale
3-6-81
Broyhill
E2-D71-5

Figure 6

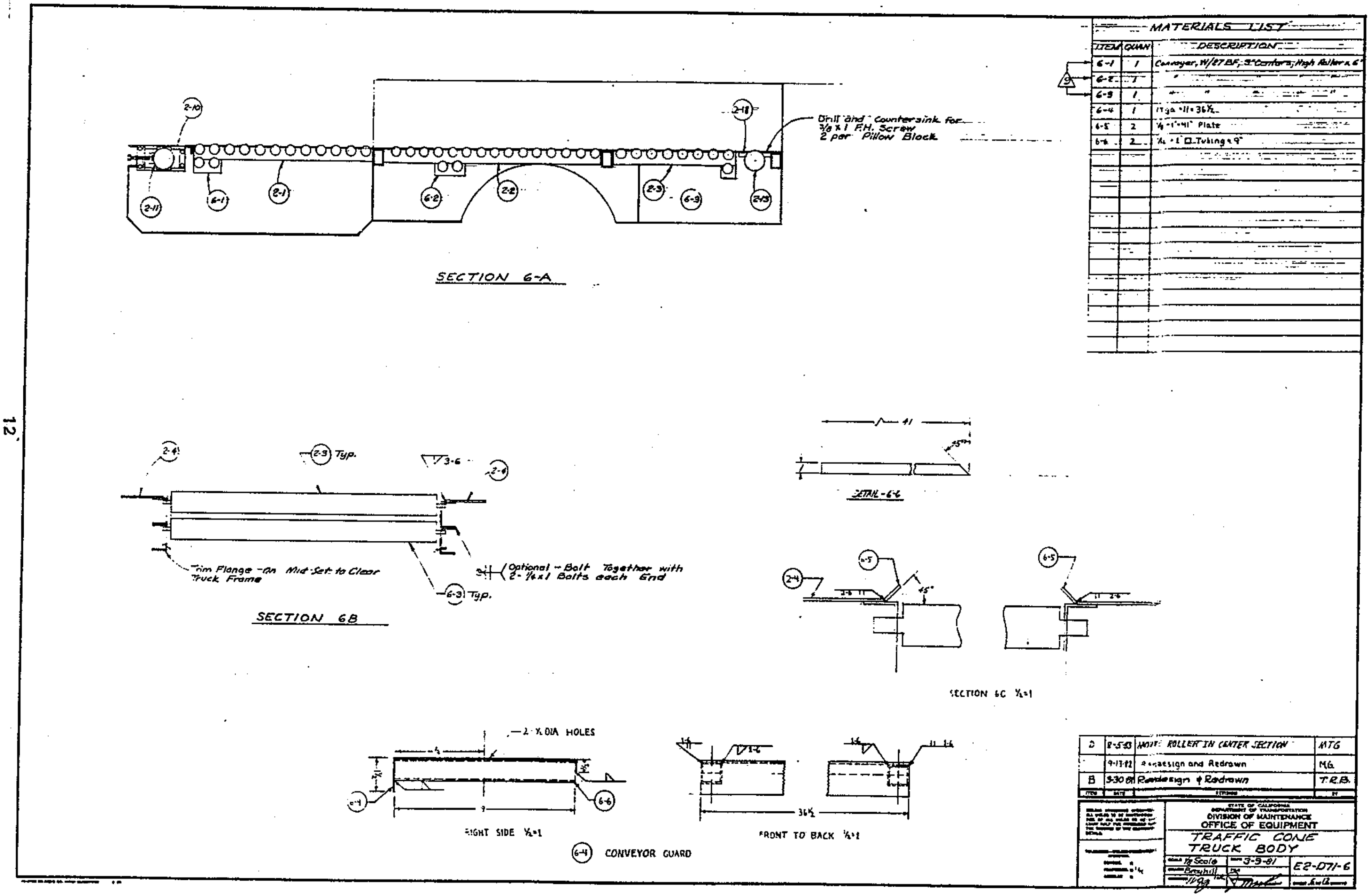

MATERIALS LIST
ITEM QUAN DESCRIPTION
6-1 1 Conveyor, W/27 BF, 3" Centers, High Rollers x 6'
6-2 1 " "
6-3 1 " "
6-4 1 11 ga x 11 x 36 1/2
6-5 2 1/4 x 1 x 41 Plate
6-6 2 1/4 x 1 ☐ Tubing x 9
Drill and Countersink for 3/8 x 1 F.H. Screw 2 per Pillow Block
SECTION 6-A
2-3 Typ.
3-6
Trim Flange - On Mid-Set to Clear Truck Frame
Optional - Bolt Together with 2 - 3/4 x 1 Bolts each End
6-3 Typ.
SECTION 6B
DETAIL - 6-6
SECTION 6C 1/2=1
2 - 3/4 DIA HOLES
RIGHT SIDE 1/2=1
FRONT TO BACK 1/2=1
36 1/2
6-4 CONVEYOR GUARD
C 8-5-83 NOTE: ROLLER IN CENTER SECTION MTG
9-13-82 Redesign and Redrawn MG
B 3-30-81 Redesign & Redrawn T.R.B.
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
TRAFFIC CONE TRUCK BODY
1/8 Scale
3-9-81
E2-071-6

Figure 7

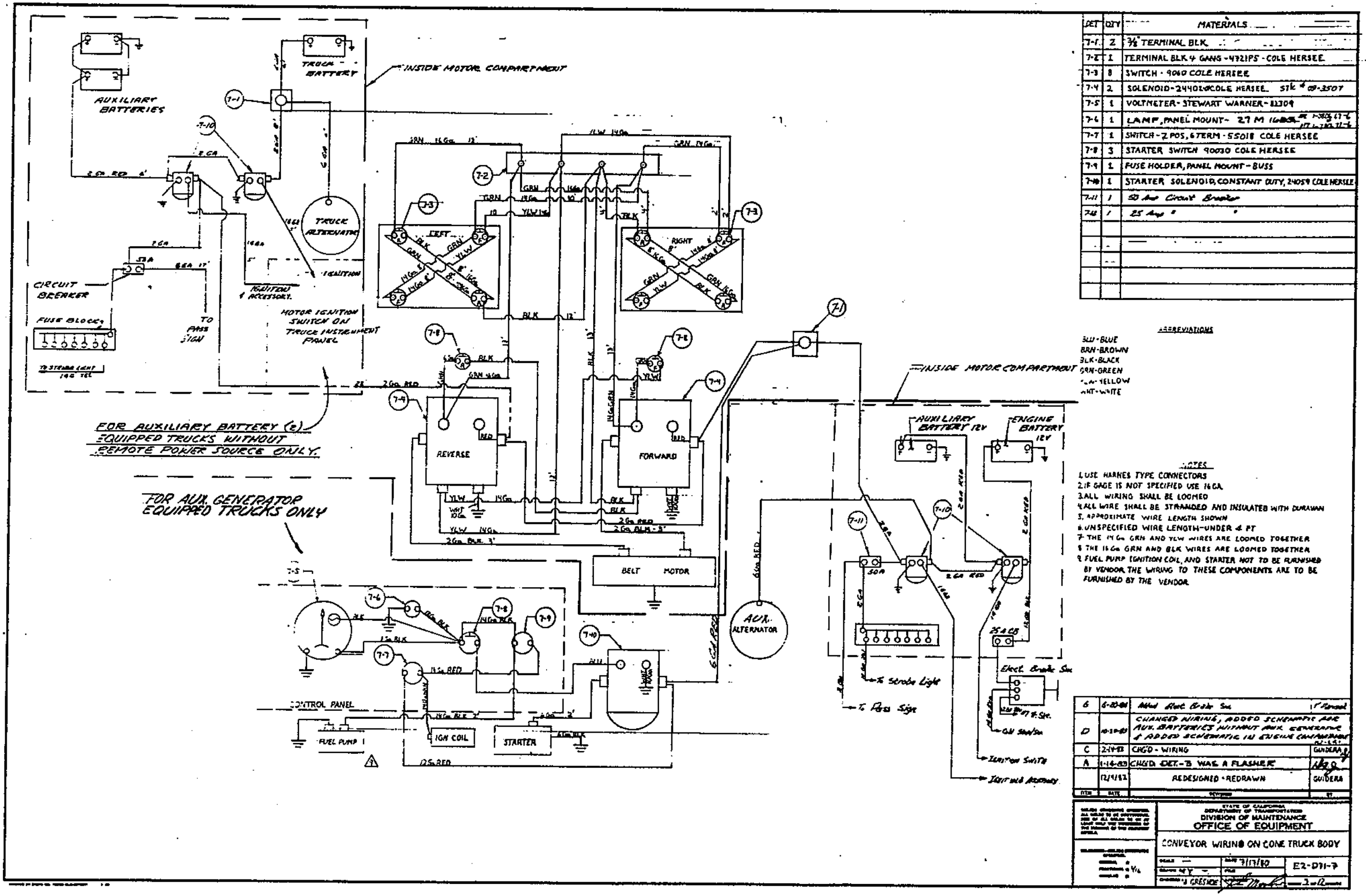

MATERIALS
7-1 2 3/8" TERMINAL BLK.
7-2 1 TERMINAL BLK 4 GANG -4721PS - COLE HERSEE
7-3 8 SWITCH - 9060 COLE HERSEE
7-4 2 SOLENOID-24401-COLE HERSEE
7-5 1 VOLTMETER - STEWART WARNER - 82309
7-6 1 LAMP, PANEL MOUNT - 27 M
7-7 1 SWITCH - 2 POS, 6 TERM - 55018 COLE HERSEE
7-8 3 STARTER SWITCH 90030 COLE HERSEE
7-9 1 FUSE HOLDER, PANEL MOUNT - BUSS
7-10 1 STARTER SOLENOID, CONSTANT DUTY, 24059 COLE HERSEE
7-11 1 50 Amp Circuit Breaker
7-12 1 25 Amp "
ABBREVIATIONS
BLU-BLUE
BRN-BROWN
BLK-BLACK
GRN-GREEN
YLW-YELLOW
WHT-WHITE
NOTES
1. USE HARNES TYPE CONNECTORS
2. IF GAGE IS NOT SPECIFIED USE 16 GA.
3. ALL WIRING SHALL BE LOOMED
4. ALL WIRE SHALL BE STRANDED AND INSULATED WITH DURAWAN
5. APPROXIMATE WIRE LENGTH SHOWN
6. UNSPECIFIED WIRE LENGTH - UNDER 4 FT
7. THE 14 Ga GRN AND YLW WIRES ARE LOOMED TOGETHER
8. THE 16 Ga GRN AND BLK WIRES ARE LOOMED TOGETHER
9. FUEL PUMP IGNITION COIL, AND STARTER NOT TO BE FURNISHED BY VENDOR. THE WIRING TO THESE COMPONENTS ARE TO BE FURNISHED BY THE VENDOR.
AUXILIARY BATTERIES
TRUCK BATTERY
INSIDE MOTOR COMPARTMENT
TRUCK ALTERNATOR
IGNITION
IGNITION & ACCESSORY.
MOTOR IGNITION SWITCH ON TRUCK INSTRUMENT PANEL
CIRCUIT BREAKER
FUSE BLOCK
TO PASS SIGN
LEFT
RIGHT
REVERSE
FORWARD
BELT MOTOR
FOR AUXILIARY BATTERY (2) EQUIPPED TRUCKS WITHOUT REMOTE POWER SOURCE ONLY.
FOR AUX. GENERATOR EQUIPPED TRUCKS ONLY
CONTROL PANEL
FUEL PUMP
IGN COIL
STARTER
AUX. ALTERNATOR
AUXILIARY BATTERY 12V
ENGINE BATTERY 12V
Elect. Brake Sw.
To Strobe Light
To Pass Sign
Ignition Switch
6 | 6-23-84 | Added Elect Brake Sw.
D | CHANGED WIRING, ADDED SCHEMATIC FOR AUX. BATTERIES WITHOUT AUX. GENERATOR & ADDED SCHEMATIC IN ENGINE COMPARTMENT
C | 2-14-83 | CHGD - WIRING | GUIDERA
A | 1-14-83 | CHGD DET.-3 WAS A FLASHER
12/4/82 | REDESIGNED - REDRAWN | GUIDERA
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
CONVEYOR WIRING ON CONE TRUCK BODY
E2-D11-7

Figure 8

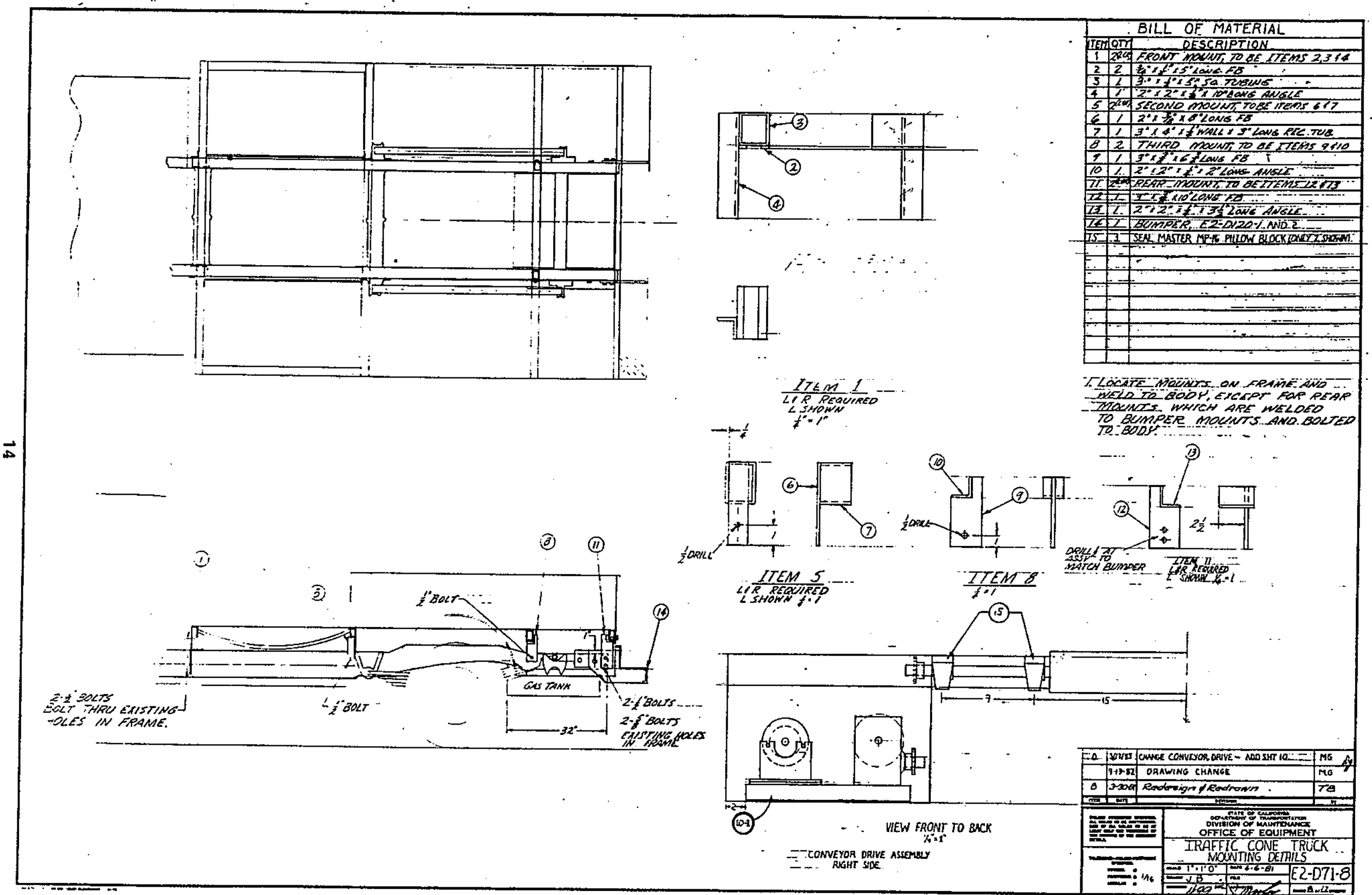
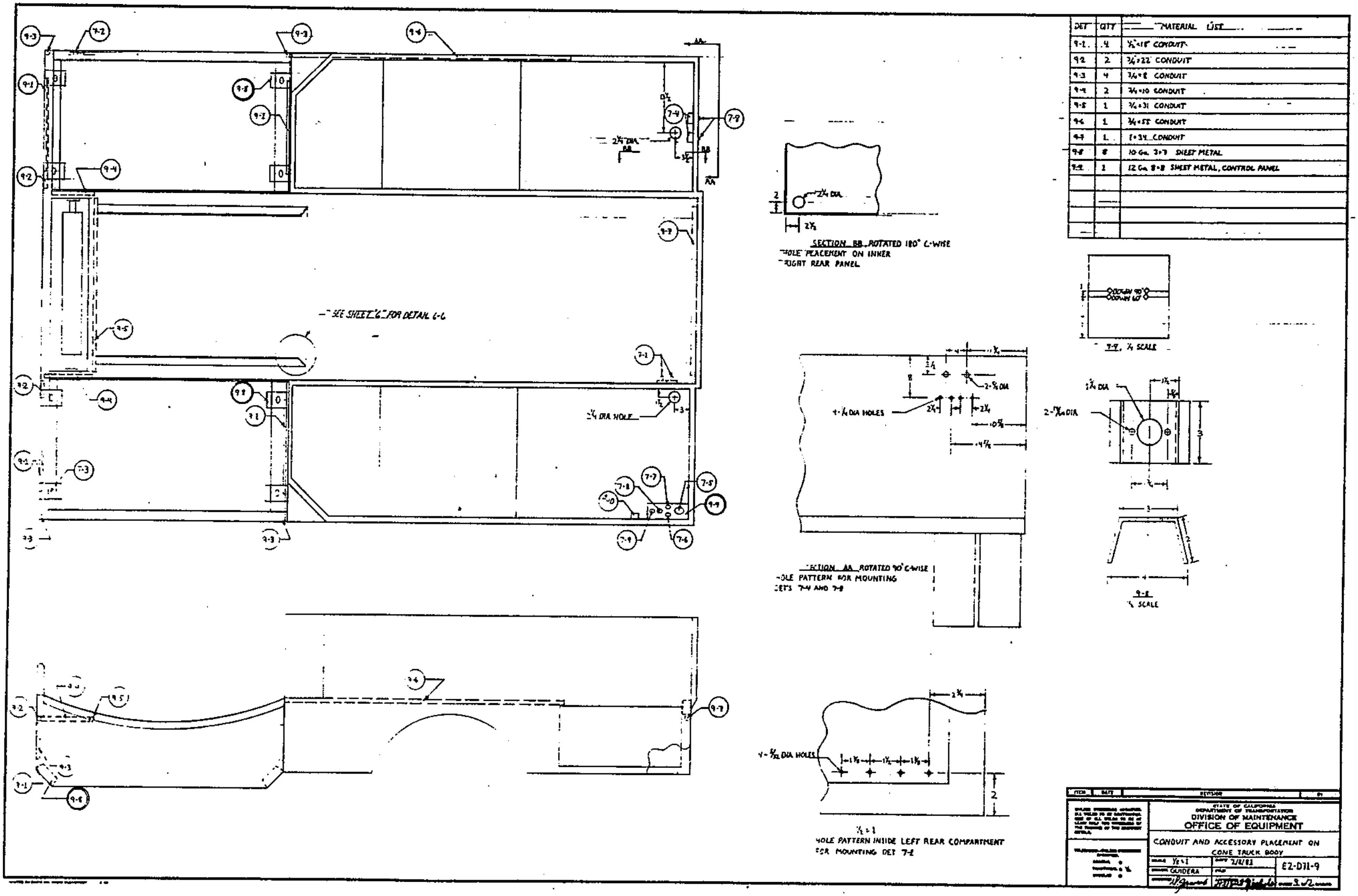
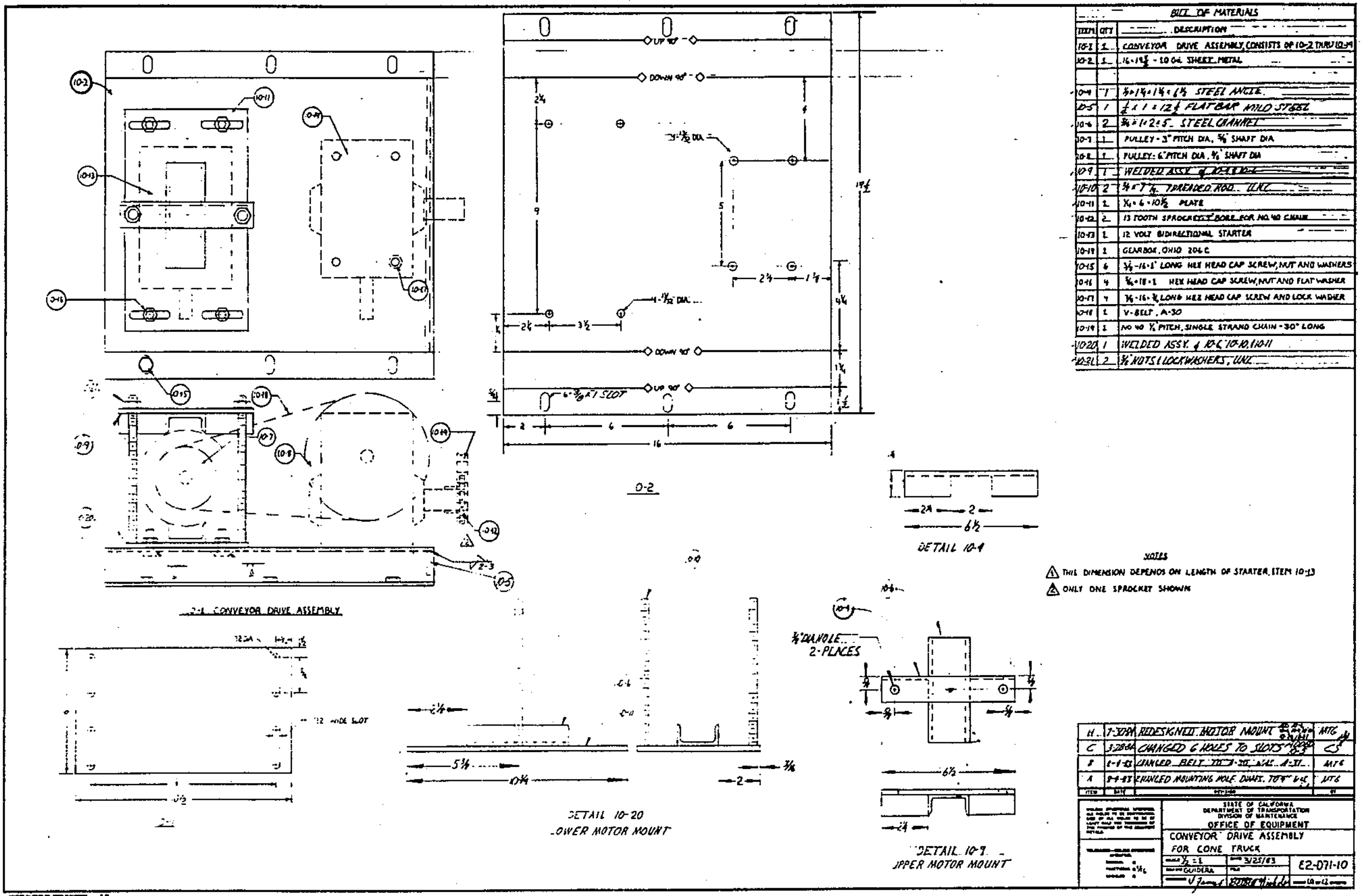

BILL OF MATERIAL
ITEM QTY DESCRIPTION
1 2 FRONT MOUNT, TO BE ITEMS 2,3 & 4
2 2 3/4" x 1 1/2" x 5" LONG FB
3 1 3" x 1/4" x 5" SQ. TUBING
4 1 2" x 2" x 1/4" x 10" LONG ANGLE
5 2 SECOND MOUNT, TO BE ITEMS 6 & 7
6 1 2" x 3/8" x 8" LONG FB
7 1 3" x 4" x 1/4" WALL x 3" LONG REC. TUB.
8 2 THIRD MOUNT, TO BE ITEMS 9 & 10
9 1 3" x 3/8" x 6 1/2" LONG FB
10 1 2" x 2" x 1/4" x 2" LONG ANGLE
11 2 REAR MOUNT, TO BE ITEMS 12 & 13
12 1 3" x 3/8" x 10" LONG FB
13 1 2" x 2" x 1/4" x 3 1/2" LONG ANGLE
14 1 BUMPER, E2-D120-1 AND 2
15 1 SEAL MASTER MP-16 PILLOW BLOCK (ONLY 1 SHOWN)
1. LOCATE MOUNTS ON FRAME AND WELD TO BODY, EXCEPT FOR REAR MOUNTS WHICH ARE WELDED TO BUMPER MOUNTS AND BOLTED TO BODY.
ITEM 1
L & R REQUIRED
L SHOWN
1/2" = 1"
1/2 DRILL
ITEM 5
L & R REQUIRED
L SHOWN 1/2:1
ITEM 8
1/2:1
DRILL AT ASSY TO MATCH BUMPER
ITEM 11
L & R REQUIRED
L SHOWN 1/2:1
2 1/2
1/2" BOLT
GAS TANK
32"
2-1/2" BOLTS
2-5/8" BOLTS
EXISTING HOLES IN FRAME
2-1/2" BOLTS
BOLT THRU EXISTING HOLES IN FRAME.
1/2" BOLT
VIEW FRONT TO BACK
1/4" = 1"
CONVEYOR DRIVE ASSEMBLY
RIGHT SIDE
7
15
C 3/7/83 CHANGE CONVEYOR DRIVE - ADD SHT 10 MG
9-13-82 DRAWING CHANGE MG
B 3-30-81 Redesign & Redrawn TB
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
TRAFFIC CONE TRUCK
MOUNTING DETAILS
1" = 1'-0"
6-6-81
E2-D71-8

Figure 9



MATERIAL LIST
DET | QTY
9-1 | 4 | ½×18 CONDUIT
9-2 | 2 | ¾×22 CONDUIT
9-3 | 4 | ¾×8 CONDUIT
9-4 | 2 | ¾×10 CONDUIT
9-5 | 1 | ¾×31 CONDUIT
9-6 | 1 | ¾×55 CONDUIT
9-7 | 1 | 1×34 CONDUIT
9-8 | 8 | 10 Ga. 3×7 SHEET METAL
9-9 | 1 | 12 Ga. 8×8 SHEET METAL, CONTROL PANEL
SEE SHEET "6" FOR DETAIL 6-6
SECTION BB ROTATED 180° C-WISE
HOLE PLACEMENT ON INNER
RIGHT REAR PANEL
SECTION AA ROTATED 90° C-WISE
HOLE PATTERN FOR MOUNTING
DETS 7-4 AND 7-8
½ = 1
HOLE PATTERN INSIDE LEFT REAR COMPARTMENT
FOR MOUNTING DET 7-2
4-¼ DIA HOLES
4-5/32 DIA HOLES
2¼ DIA HOLE
2-7/16 DIA
9-9, ¼ SCALE
9-8, ½ SCALE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
CONDUIT AND ACCESSORY PLACEMENT ON
CONE TRUCK BODY
½ = 1
2/4/83
GUIDERA
E2-D11-9

Figure 10



BILL OF MATERIALS
ITEM | QTY | DESCRIPTION
10-1 | 1 | CONVEYOR DRIVE ASSEMBLY, CONSISTS OF 10-2 THRU 10-19
10-2 | 1 | 16 × 19½ - 10 GA. SHEET METAL
10-4 | 1 | ⅛ × 1¼ × 1¼ × 6½ STEEL ANGLE
10-5 | 1 | ¼ × 1 × 12½ FLAT BAR MILD STEEL
10-6 | 2 | ⅛ × 1 × 2 × 5 STEEL CHANNEL
10-7 | 1 | PULLEY - 3" PITCH DIA., ⅝" SHAFT DIA
10-8 | 1 | PULLEY - 6" PITCH DIA., ⅝" SHAFT DIA
10-9 | 1 | WELDED ASSY.
10-10 | 2 | ⅜ × 7½ THREADED ROD, UNC
10-11 | 1 | 3/16 × 6 × 10½ PLATE
10-12 | 2 | 13 TOOTH SPROCKET, BORE, FOR NO. 40 CHAIN
10-13 | 1 | 12 VOLT BIDIRECTIONAL STARTER
10-14 | 1 | GEARBOX, OHIO 206C
10-15 | 6 | 5/16 - 18 × 1" LONG HEX HEAD CAP SCREW, NUT AND WASHERS
10-16 | 4 | 5/16 × 18 × 1 HEX HEAD CAP SCREW, NUT AND FLAT WASHER
10-17 | 4 | ⅜ - 16 × ¾ LONG HEX HEAD CAP SCREW AND LOCK WASHER
10-18 | 1 | V-BELT, A-30
10-19 | 1 | NO. 40 ½" PITCH, SINGLE STRAND CHAIN - 30" LONG
10-20 | 1 | WELDED ASSY. & 10-6, 10-10, 10-11
10-21 | 2 | ⅜ NUTS & LOCKWASHERS, UNC
NOTES
1. THIS DIMENSION DEPENDS ON LENGTH OF STARTER, ITEM 10-13
2. ONLY ONE SPROCKET SHOWN
10-1 CONVEYOR DRIVE ASSEMBLY
10-2
DETAIL 10-4
DETAIL 10-20 LOWER MOTOR MOUNT
DETAIL 10-9 UPPER MOTOR MOUNT
⅜ DIA. HOLE 2-PLACES
6-⅜ × 1 SLOT
UP 90°
DOWN 90°
H | 7-30-84 | REDESIGNED MOTOR MOUNT
C | 3-28-84 | CHANGED 6 HOLES TO SLOTS
B | 1-4-83 | CHANGED BELT
A | 9-9-83 | CHANGED MOUNTING HOLE DIMS.
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF MAINTENANCE
OFFICE OF EQUIPMENT
CONVEYOR DRIVE ASSEMBLY
FOR CONE TRUCK
3/25/83
GUIDERA
E2-071-10

Figure 11

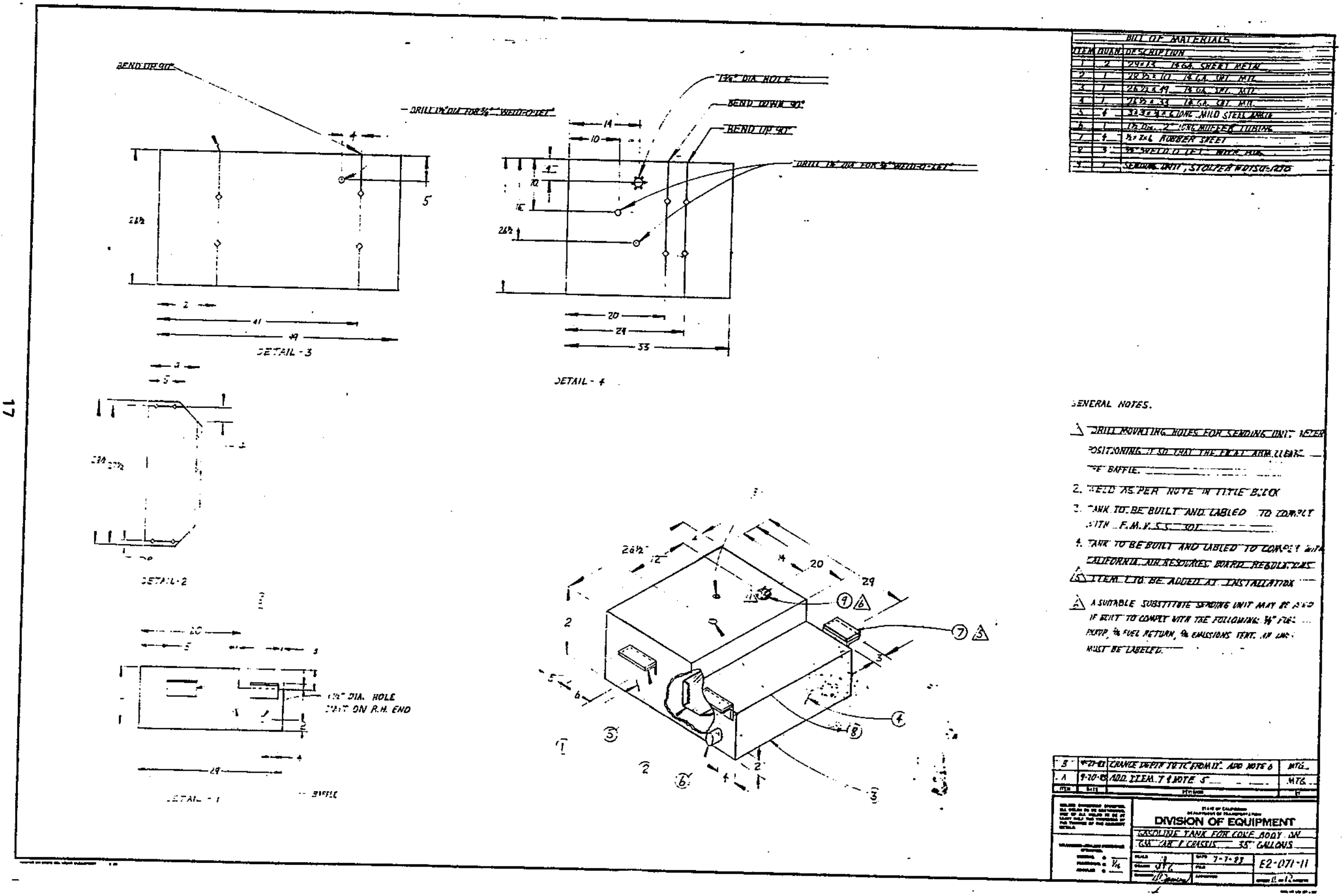

BILL OF MATERIALS
ITEM | QUAN | DESCRIPTION
1 | 2 | 29x13 14GA. SHEET METAL
2 | 1 | 28½x10 14 GA. SHT. MTL.
3 | 1 | 26½x49 14 GA. SHT. MTL.
4 | 1 | 28½x33 14 GA. SHT. MTL.
5 | 4 | 3x3x¼x6 LONG MILD STEEL ANGLE
6 | 1 | 1½ Dia. 2" LONG RUBBER TUBING
7 | 4 | ½x2x6 RUBBER SHEET
8 | 3 | WELD-O-LET WITH PLUG
9 | 1 | SENDING UNIT, STOLPER #0TSU-5/R70
GENERAL NOTES.
1. DRILL MOUNTING HOLES FOR SENDING UNIT AFTER POSITIONING IT SO THAT THE FLOAT ARM CLEARS THE BAFFLE.
2. WELD AS PER NOTE IN TITLE BLOCK
3. TANK TO BE BUILT AND LABLED TO COMPLY WITH F.M.V.S.S. 301
4. TANK TO BE BUILT AND LABLED TO COMPLY WITH CALIFORNIA AIR RESOURCES BOARD REGULATIONS
5. ITEM 7 TO BE ADDED AT INSTALLATION
6. A SUITABLE SUBSTITUTE SENDING UNIT MAY BE USED IF BUILT TO COMPLY WITH THE FOLLOWING: ⅜" FUEL PUMP, ⅜ FUEL RETURN, ⅜ EMISSIONS VENT. ALL LINES MUST BE LABELED.
BEND UP 90°
DRILL 1⅛" DIA FOR ¾" WELD-O-LET
DETAIL - 3
1⅝" DIA. HOLE
BEND DOWN 90°
BEND UP 90°
DRILL 1⅛" DIA FOR ¾" WELD-O-LET
DETAIL - 4
DETAIL - 2
1½" DIA. HOLE
UNIT ON R.H. END
DETAIL - 1
BAFFLE
B | 9-27-83 | CHANGE DEPTH TO 16" FROM 12". ADD NOTE 6 | MTG
A | 9-20-83 | ADD ITEM 7 & NOTE 5 | MTG
DIVISION OF EQUIPMENT
GASOLINE TANK FOR CONE BODY ON GM CAB & CHASSIS 35 GALLONS
7-7-83
E2-071-11

Figure 12

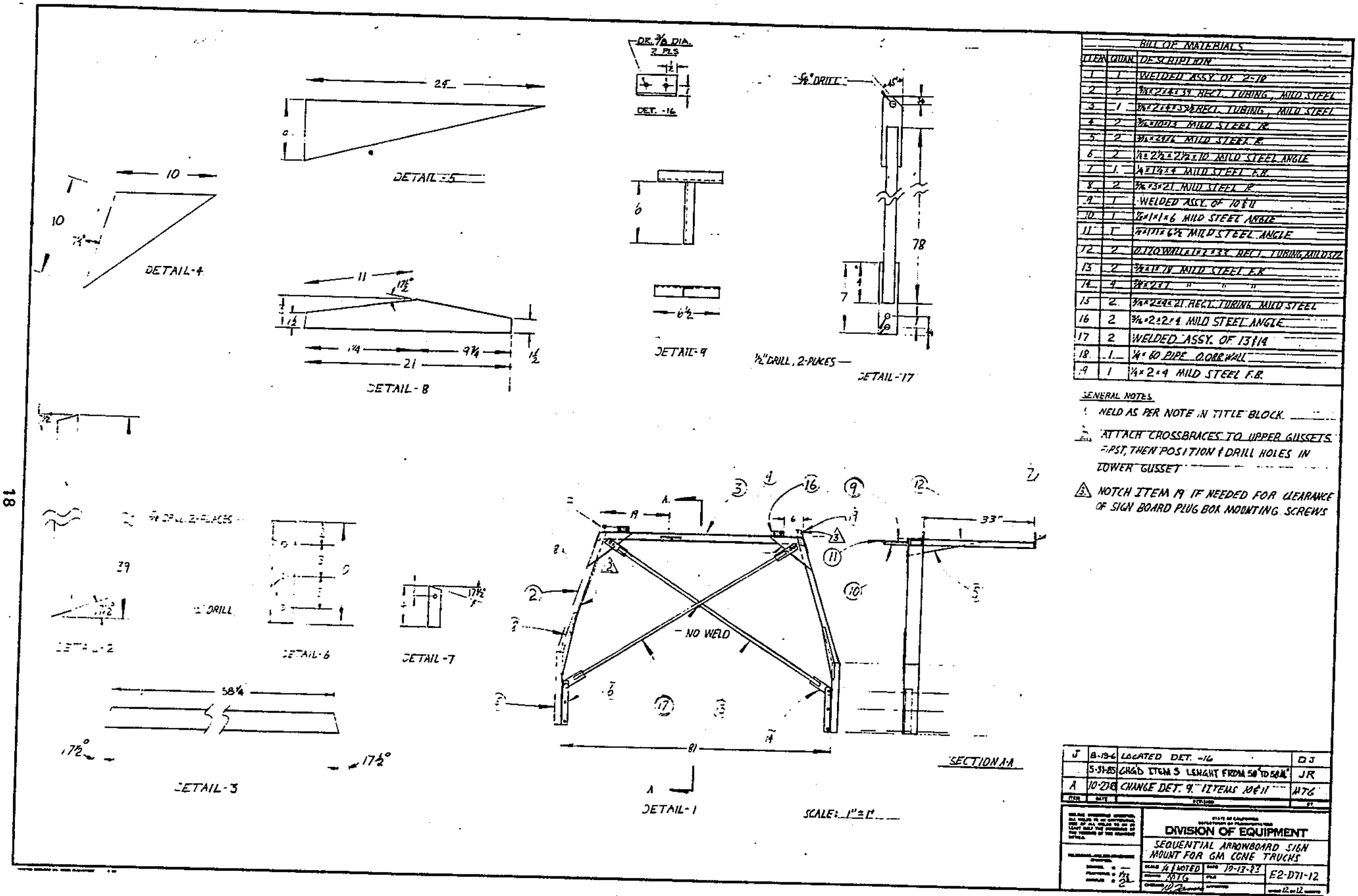

BILL OF MATERIALS
ITEM QUAN DESCRIPTION
1 1 WELDED ASSY. OF 2-10
2 2 3/16x2x4x39 RECT. TUBING, MILD STEEL
3 1 3/16x2x4x58 3/4 RECT. TUBING, MILD STEEL
4 2 3/16x10x13 MILD STEEL PL
5 2 3/16x24x6 MILD STEEL PL
6 2 1/4x2 1/2x2 1/2x10 MILD STEEL ANGLE
7 1 1/4x1 1/4x4 MILD STEEL F.B.
8 2 3/16x3x21 MILD STEEL PL
9 1 WELDED ASSY. OF 10 & 11
10 1 1/8x1x1x6 MILD STEEL ANGLE
11 1 1/8x1x1x6 1/2 MILD STEEL ANGLE
12 2 0.120 WALL x 1x2x33 RECT. TUBING, MILD STL
13 2 3/16x1x78 MILD STEEL F.B.
14 4 3/16x2x7 " " "
15 2 3/16x2x4x21 RECT. TUBING MILD STEEL
16 2 3/16x2x2x4 MILD STEEL ANGLE
17 2 WELDED ASSY. OF 13 & 14
18 1 1/4x60 PIPE 0.088 WALL
19 1 1/4x2x4 MILD STEEL F.B.
GENERAL NOTES
1 WELD AS PER NOTE IN TITLE BLOCK.
2 ATTACH CROSSBRACES TO UPPER GUSSETS FIRST, THEN POSITION & DRILL HOLES IN LOWER GUSSET
3 NOTCH ITEM 19 IF NEEDED FOR CLEARANCE OF SIGN BOARD PLUG BOX MOUNTING SCREWS
DETAIL-4
DETAIL-5
DETAIL-8
DET. -16
DR. 3/8 DIA. 2 PLS
DETAIL-9
9/16" DRILL
1/2" DRILL, 2-PLACES
DETAIL-17
DETAIL-2
DETAIL-6
DETAIL-7
DETAIL-3
NO WELD
DETAIL-1
SECTION A-A
SCALE: 1"=1'
J 8-19-86 LOCATED DET. -16 DJ
5-31-85 CHGD ITEM 3 LENGHT FROM 58 TO 58 3/4" JR
A 10-27-83 CHANGE DET. 9 ITEMS 10 & 11 MTG
DIVISION OF EQUIPMENT
SEQUENTIAL ARROWBOARD SIGN MOUNT FOR GM CONE TRUCKS
NOTED
10-13-83
E2-D71-12

Figure 13

6.1.3 Test Vehicles

Following is a list of the passenger cars used for the cone truck tests:

Test Number	Description	Weight (lbs)
421	1978 Dodge 4-door	4130
422	1978 Chrysler 4-door	4180
423	1980 Dodge 4-door	4000
424	1975 Plymouth 4-door	3660

All vehicles were self-propelled. Steering control was achieved with a straight anchored guidance cable running through a bracket attached to the right front wheel. No constraints were placed on the steering wheel. A short distance before the point of impact, the vehicle ignition was turned off, and the car was released from the guidance cable. A speed control device on the car maintained the desired impact speed once it was attained.

The same cone truck was used in all tests.

Description	Total Weight
1967 Ford 10000 GVW	6200 lbs

The truck was a retired Caltrans vehicle, in running condition, free of body damage or missing structural parts, and unmodified for tests.

In all tests the truck was parked in second gear (standard transmission).

Two lightweight steel tube frames with targeting were cantilevered off the top of the cone body of the truck. They permitted smaller more detailed fields of view in the data cameras without sacrificing the means to plot the truck displacement and velocity.

6.1.4 Data Acquisition Systems

Several high speed movie cameras were used to record the impact events. A normal speed movie camera, a video camera, and a colored slide camera were used also to picture the impact and the conditions of the test vehicles before and after the impact. In addition black and white still photography was used to cover pre and post impact test conditions.

Accelerometers were mounted on the floorboard of the car and on the floorboard in the truck cab. Acceleration data were collected to judge impact severity and the chance of operator injury.

In the tests, an anthropomorphic dummy was placed in the cone body of the cone truck. The dummy, Sam, a dummy built to conform to Federal Motor Vehicle Safety Standards by the Sierra Engineering Company, is a 95 percentile American male weighing 185 lbs. The dummy was restrained with a standard lap belt for all tests.

All high speed cameras were equipped with timing light generators which exposed reddish timing pips on the film at a rate of 1,000 per second. The pips were used to determine camera frame rates and to establish time-sequence relationships. Data from the high-speed movies were reduced on a Vanguard Analyzer.

Some procedures used to facilitate data reduction for the test are listed as follows:

Butterfly targets were attached to the cone truck and cars at specified locations to collect data from the films and photographs.

6.1.5 Test Parameters

Test No.	Speed	Angle(degrees)	Impact location on Cone Truck
421	44.7 mph	0^{o}	℄ of car on right rear
422	45.1 mph	25^{o}	℄ of car on left front corner of cone body
423	43.4 mph	25^{o}	℄ of car on right front cone of cone body
424	61.8 mph	25^{o}	℄ of car on right front cone of cone body

6.2 Cone Truck Test Result

There were four tests conducted to help determine the crash worthiness of the cone truck body. A film report was also assembled which shows all tests.

6.2.1 Test 421

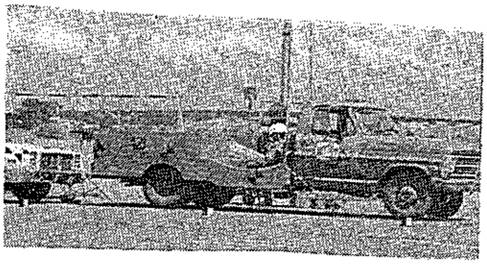
Test 421 was a rear impact of the cone truck body. This test was conducted to determine if the sheet metal on the rear of the body would absorb the impact without damaging the operator's compartment, and also view the reaction of Sam (dummy) during impact.

Data sheet and photos of vehicles before and after impact are shown in figures 421-1 through 421-4.

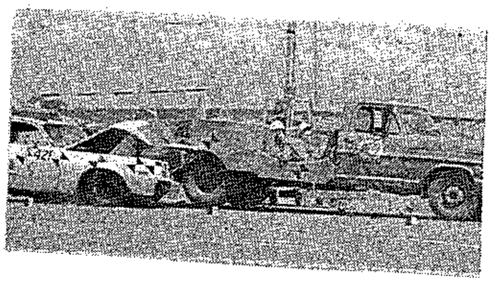
The car's longitudinal centerline impacted inline with the right side and rear of the cone truck at 44.7 mph.

The rear sheet metal of the cone truck was severely crushed while leaving the operator's compartment damage free. Sam (dummy) was tossed about loosing his hardhat but remaining belted in his position. The cone truck was driveable after the test.

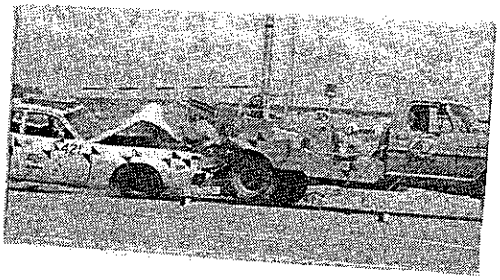
The car was severely damaged and undriveable.



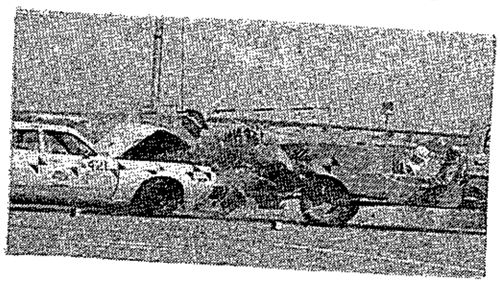
Impact + .000 seconds



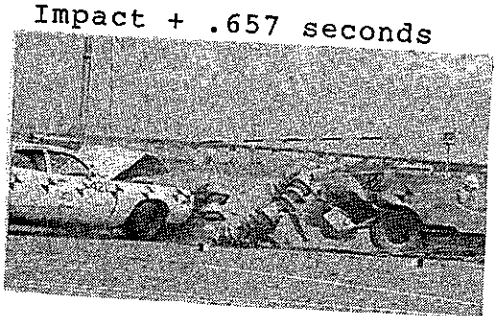
Impact + .146 seconds



Impact + .292 seconds



Impact + .657 seconds



Impact + .949 seconds

DATA SUMMARY SHEET

TEST #421

TEST DATE

AUGUST 17, 1983

CONE TRUCK DATE

Model
Gross Vehicle Weight — Ford Cab
Bed Type — 6200 lbs
Brake Setting — Conesetting
Gear Setting — Parking 1/2 engaged
2nd gear

DUMMY DATA

Dummy #1, Sierra part #292,
50 Percentile male was seated on the right side of the truck conesetting bed, facing forward.
Dummy Height - 6' Dummy Weight-221
Dummy Restraint
Lap Belt

Dummy #2, Sierra Part #572,
50 Percentile male was seated on the left side of the truck conesetting bed, facing the rear.
Dummy Height - 5-9' Dummy Weight-165
Dummy Restraint
Lap Belt

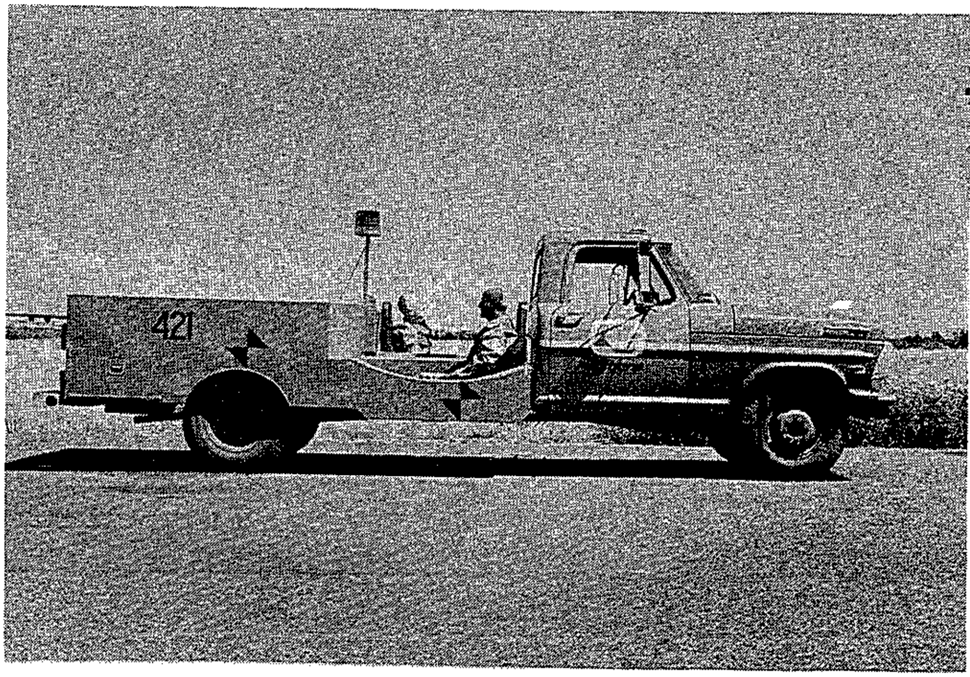
VEHICLE DATA

Model
Impact Velocity — 1978 Dodge
Impact Angle0 degree,rear — 44.7 MPH
Weight — w/3' offset
4130 lbs

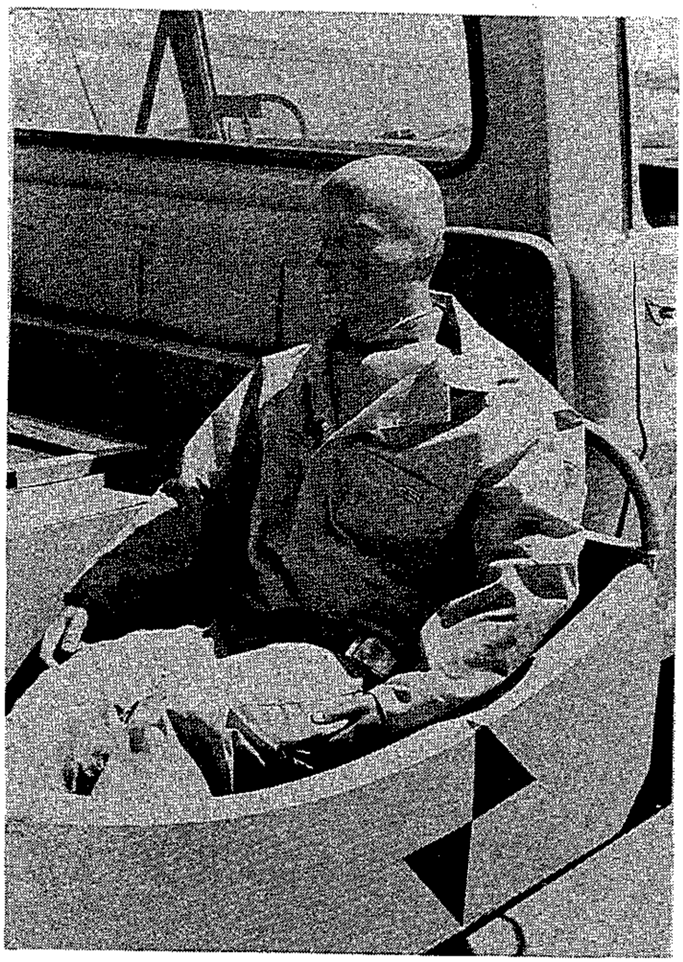
IMPACT DATA

Max. 50 MS Avg. Acceleration
Car, Longitudinal
Car, Lateral — -13.3 G
Conetruck,Longitudinal — -4.1 G
Conetruck,Lateral — 10.8 G
Dummy Head Resultant — N/A
Truck Roll Ahead Distance- — N/A
150 feet forward and left 50 feet

FIGURE 421-1



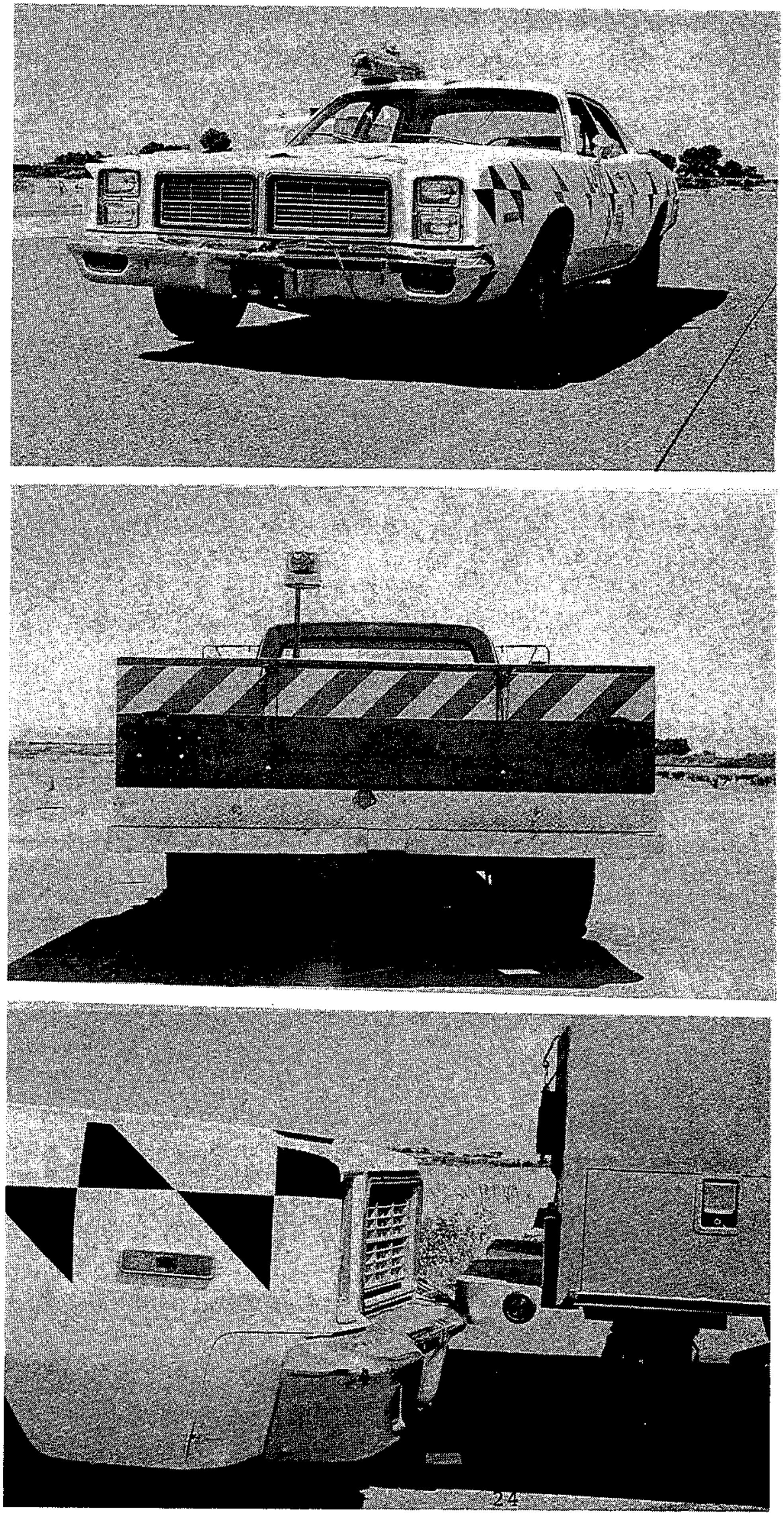
CONE TRUCK
BEFORE IMPACT



SAM BUCKLED UP
BEFORE IMPACT

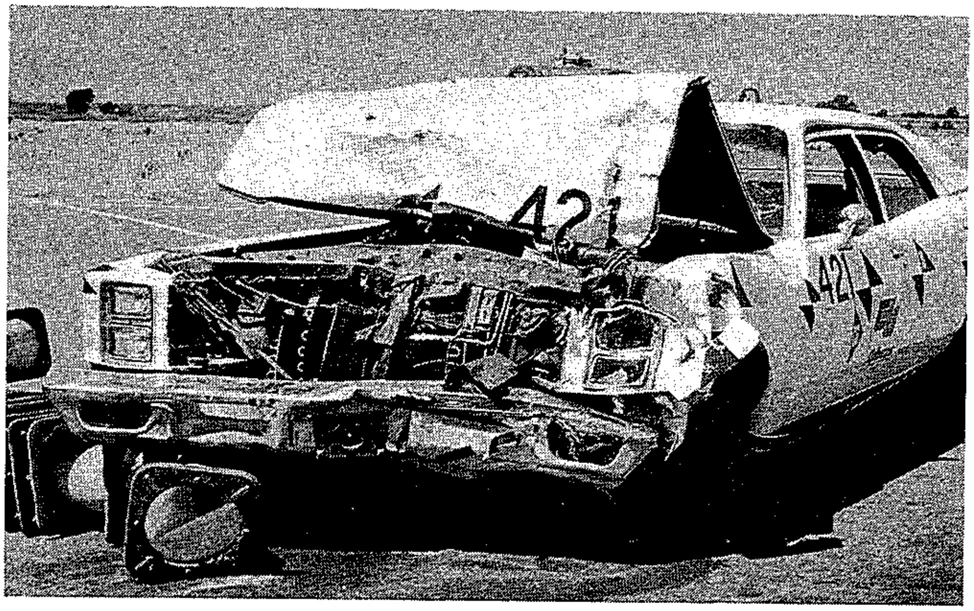
FIGURE 421-2

TEST 421

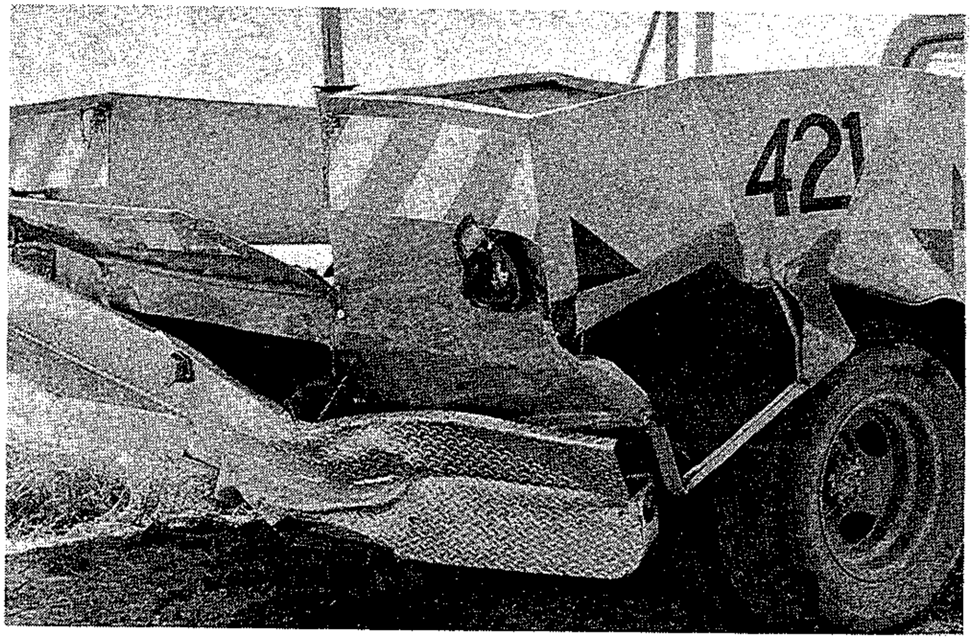


TEST VEHICLE
BEFORE IMPACT

FIGURE 421-3



TEST 421



TEST VEHICLE
AFTER IMPACT

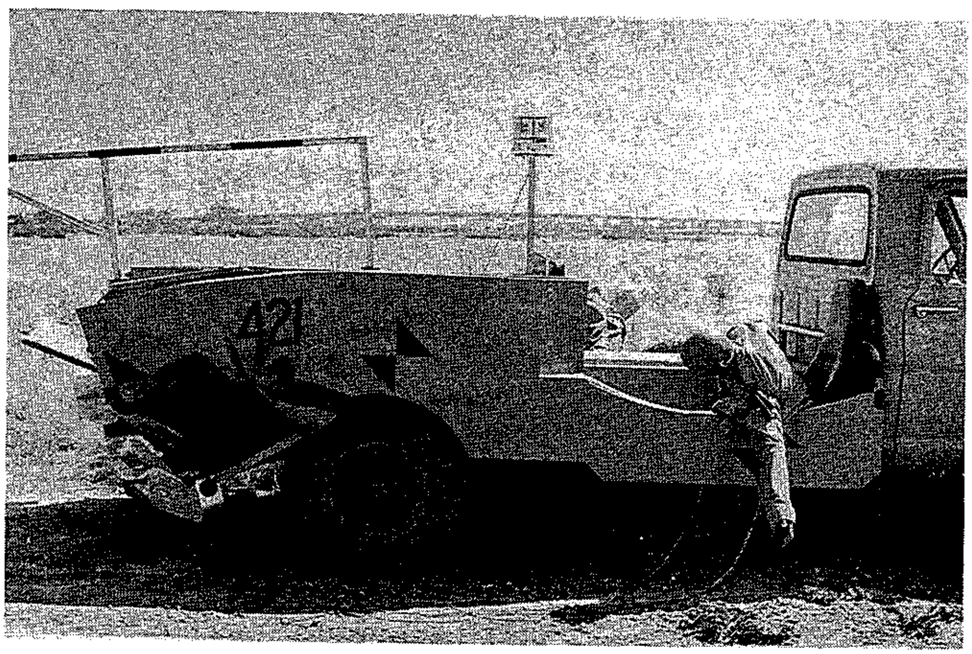


FIGURE 421-4

6.2.2 Test 422

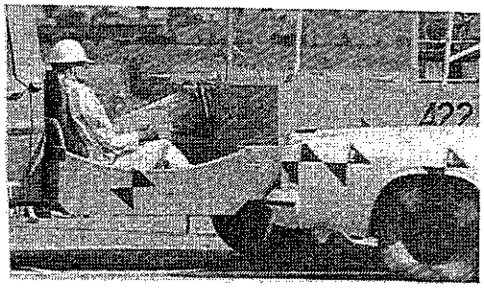
Test 422 was an angle impact of the cone truck body. This test was conducted to determine if the operator's position of the cone truck could withstand an impact by a full size passenger car, and also view Sam's reactions.

Data sheet and photos of vehicles before and after impact are shown in figures 422-1 through 422-3.

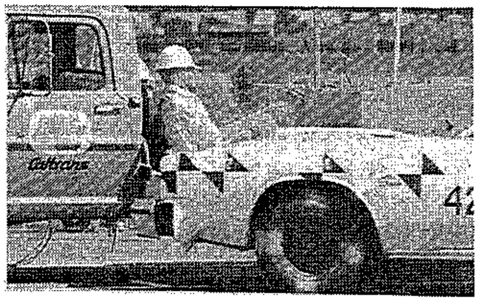
The car's longitudinal centerline impacted inline on the front left corner of the cone body at a 25° angle from the rear; this placed the impact directly on the operator's compartment.

The operator's compartment was left undamaged, only scratched paint remained. The right front corner of the car's hood penetrated the operator's position and severely damaged the right arm and knee of Sam. Sam remained belted in the operator's position. The cone truck was driveable after the test.

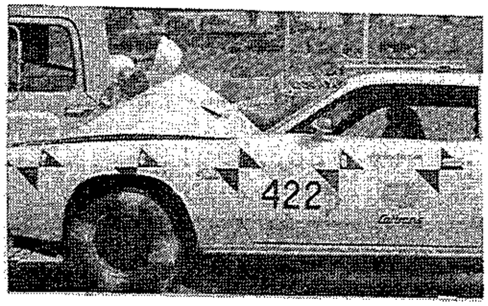
The car was severely damaged and undriveable.



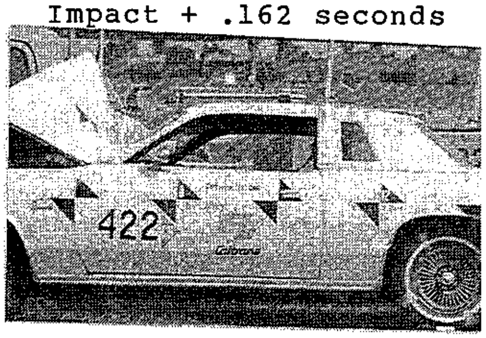
Impact + .000 seconds



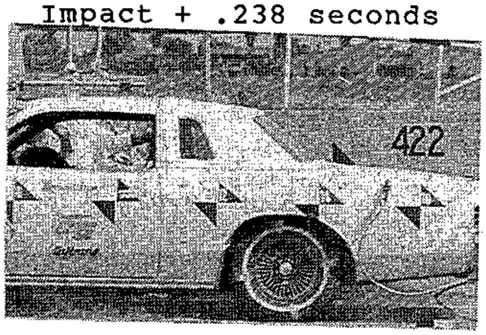
Impact + .081 seconds



Impact + .162 seconds



Impact + .238 seconds



Impact + .313 seconds

DATA SUMMARY SHEET — TEST #422

TEST DATE — SEPTEMBER 23, 1983

CONE TRUCK DATE

Model	Ford Cab
Gross Vehicle Weight	6200 lbs
Bed Type	Conesetting
Brake Setting	Parking 1/2 engaged
Gear Setting	2nd gear

DUMMY DATA

Dummy #1, Sierra part #120,
95 Percentile male was seated on the left side of the truck conesetting bed, facing the rear.

Dummy Heigtht - 6' Dummy Weight-221

Dummy Restraint — Lap Belt

Dummy #2, Sierra Part #572,
50 Percentile male was seated on the right side of the truck conesetting bed, facing the rear.

Dummy Height - 5-9' Dummy Weight-165

Dummy Restraint — Lap Belt

VEHICLE DATA

Model	1977 Chrysler
Impact Velocity	45.1 MPH
Impact Angle	25 degree/right side
Weight	4180 lbs

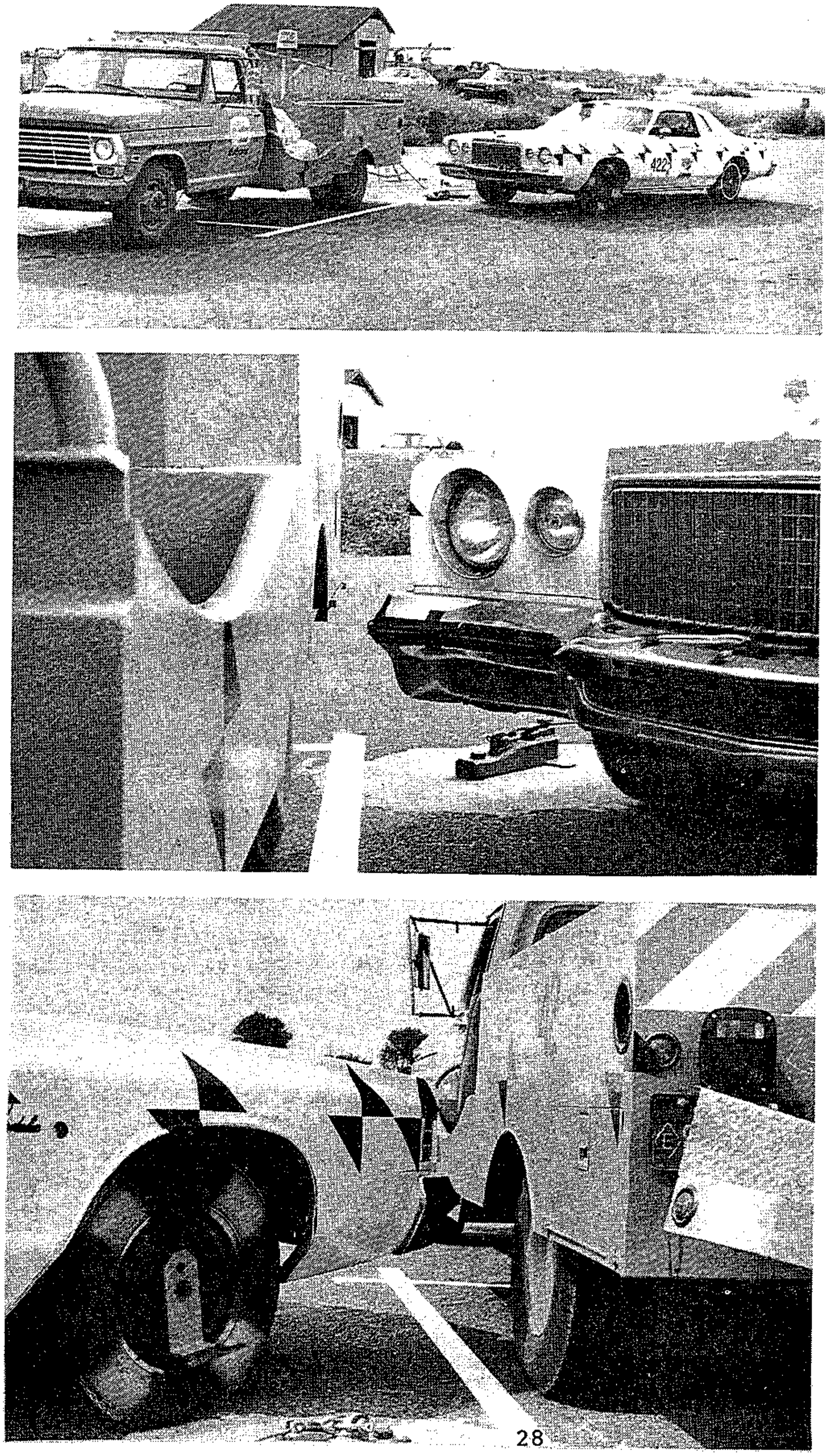
IMPACT DATA

Max. 50 MS Avg. Acceleration

Car, Longitudinal	-6.7 G
Car, Lateral	4.4 G
Conetruck,Longitudinal	3.4 G
Conetruck,Lateral	-6.2 G
Dummy Head Resultant	6.3 G

Truck Roll Ahead Distance-
14 feet and right 4 feet

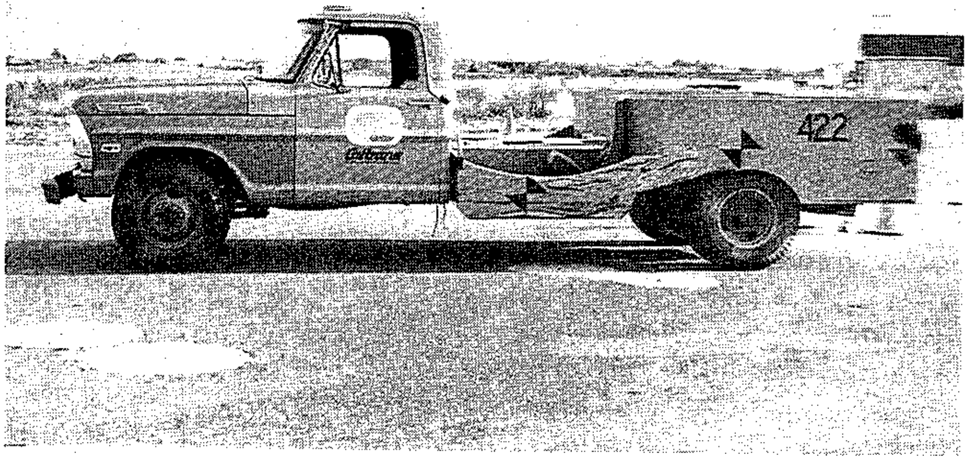
FIGURE 422-1

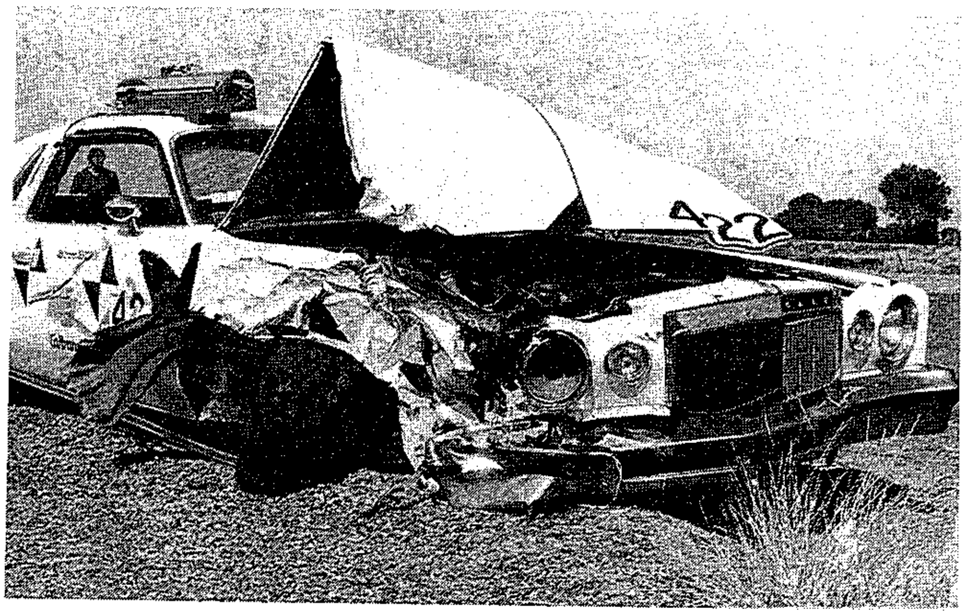


TEST VEHICLE
BEFORE IMPACT

FIGURE 422-2

TEST 422





TEST VEHICLES
AFTER IMPACT

FIGURE 422-3

6.2.3 Test 423

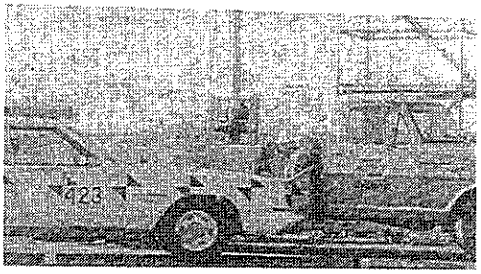
Test 423 was an angle impact of the cone truck body. This test was conducted to determine if an attachment to increase the height of the operator's compartment would prevent Sam from being damaged, as in Test 422.

The car's longitudinal centerline impacted inline on the passenger door of the cone truck at a 25° angle from the rear; this placed the impact about 10 inches forward of the impact point of Test 422.

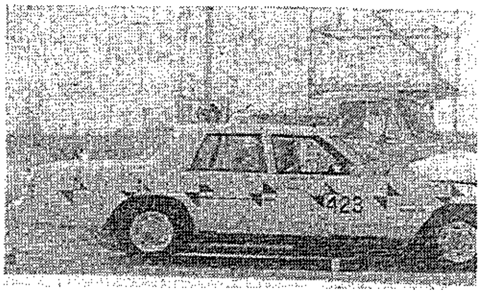
The operator's compartment was left undamaged, only scratched paint remained. Sam was tossed about but remained belted in the operator's position and was not damaged. The attachment appeared to reduce the possibility of the hood penetrating the operator's compartment. The right side of the cone truck cab and right front axle were damaged. The truck was not driveable.

The front left side of the car was severely damaged and undriveable.

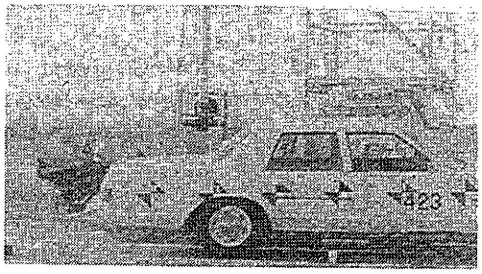
Data sheet and photos of vehicles before and after impact are shown in figures 423-1 through 423-4.



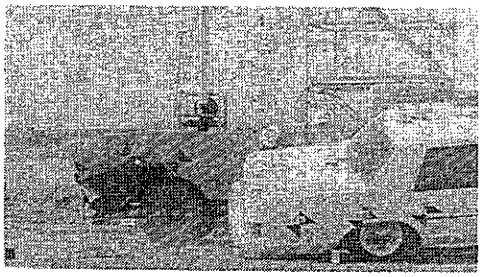
Impact + .000 seconds



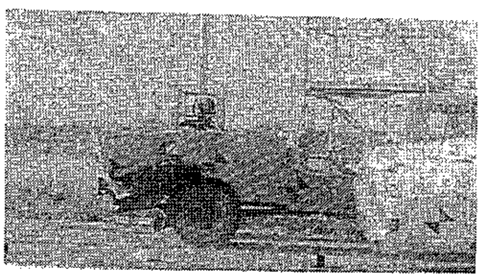
Impact + .175 seconds



Impact + .233 seconds



Impact + .350 seconds



Impact + .4668 seconds

DATA SUMMARY SHEET — TEST #423
TEST DATE — DECEMBER 11, 1984

CONE TRUCK DATE

Model	Ford Cab
Gross Vehicle Weight	6200 lbs
Bed Type	Conesetting
Brake SettingParking 1/2 engaged	
Gear Setting	2nd gear
Side Box Modifications	Yes

DUMMY DATA

Dummy #1, Sierra part #120,
95 Percentile male was seated on the right side of the truck conesetting bed, facing the rear.

Dummy Height - 6'	Dummy Weight-221
Dummy Restraint	Lap Belt

Dummy #2, Sierra Part #572,
50 Percentile male was seated on the left side of the truck conesetting bed, facing forward.

Dummy Height - 5-9'	Dummy Weight-165
Dummy Restraint	Lap Belt

VEHICLE DATA

Model	1980 Dodge
Impact Velocity	43.4 MPH
Impact Angle	25 degree/right side
Weight	4000 lbs

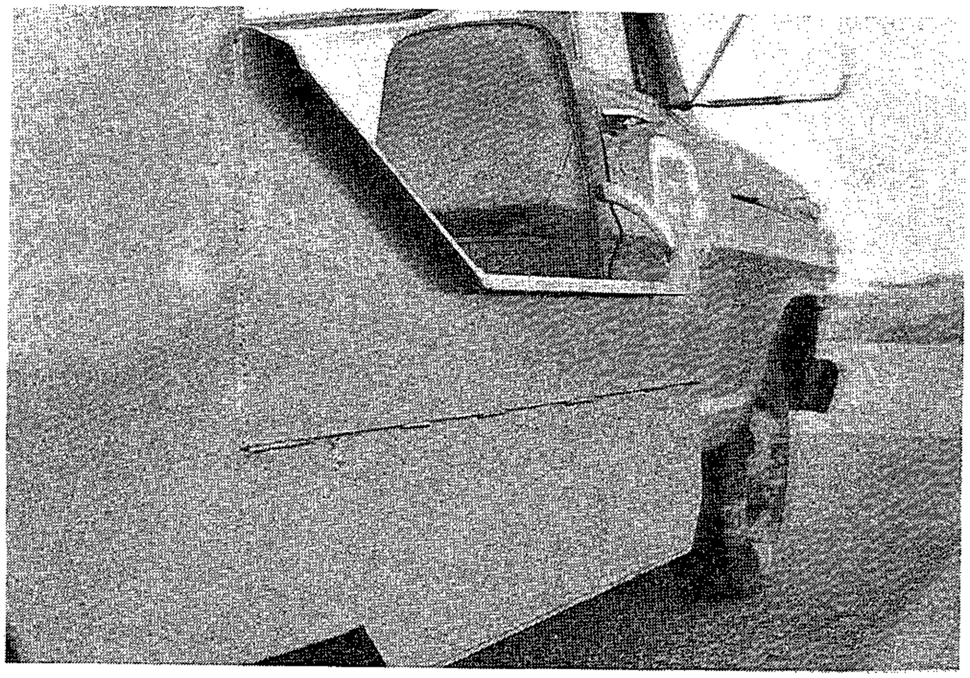
IMPACT DATA

Max. 50 MS Avg. Acceleration

Car, Longitudinal	-3.9 G
Car, Lateral	-2.9 G
Conetruck,Longitudinal	3.2 G
Conetruck,Lateral	3.6 G
Dummy Head Resultant	4.6 G
Truck Roll Ahead Distance-	N/A

FIGURE 423-1

TEST 423



ATTACHMENT ADDED
AFTER TEST 422

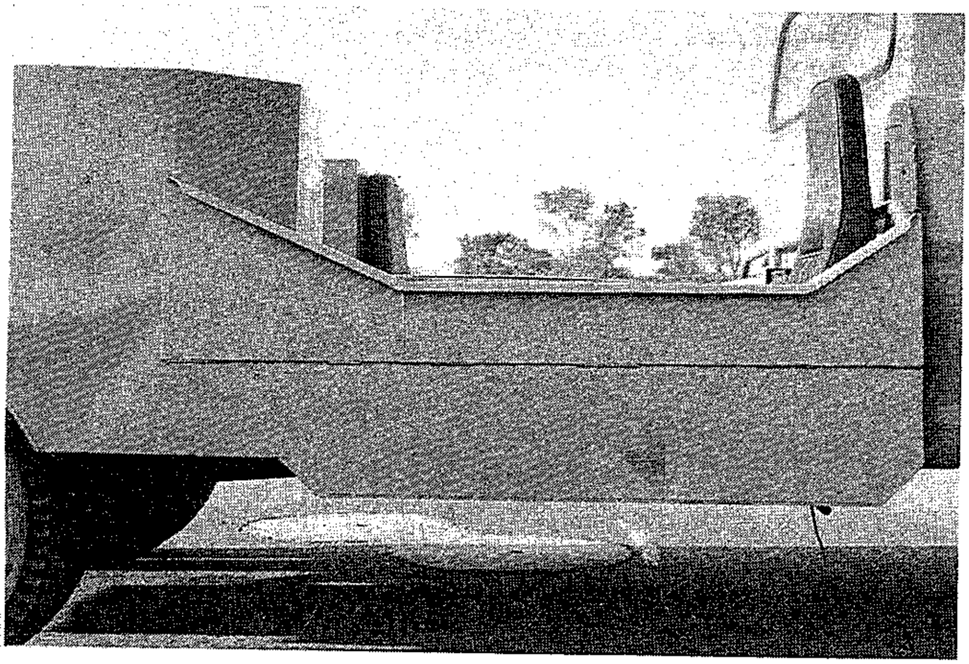
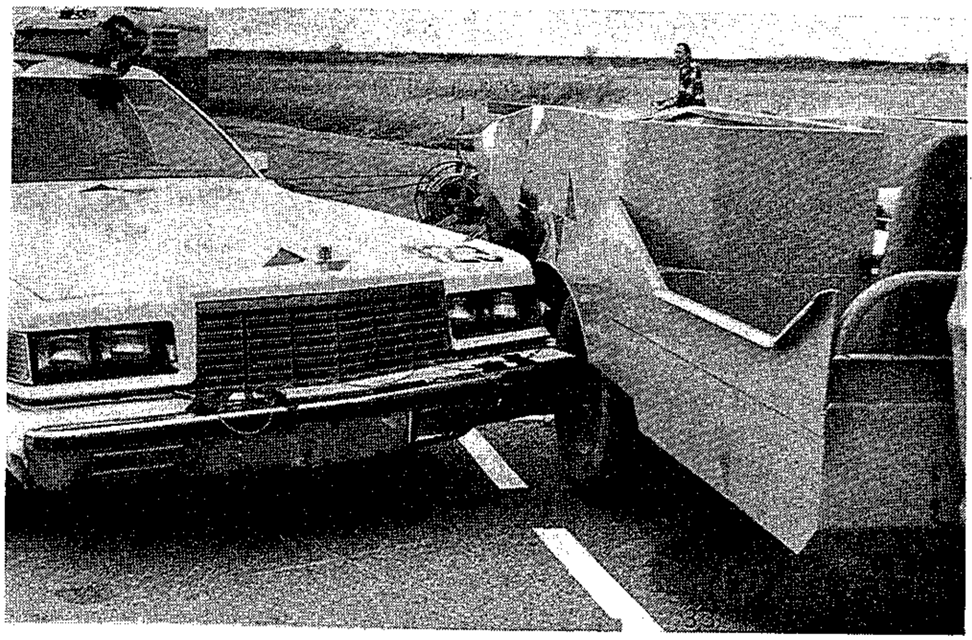


FIGURE 423-2

TEST 423



TEST VEHICLES
BEFORE IMPACT

FIGURE 423-3

TEST 423

TEST VEHICLES
AFTER IMPACT

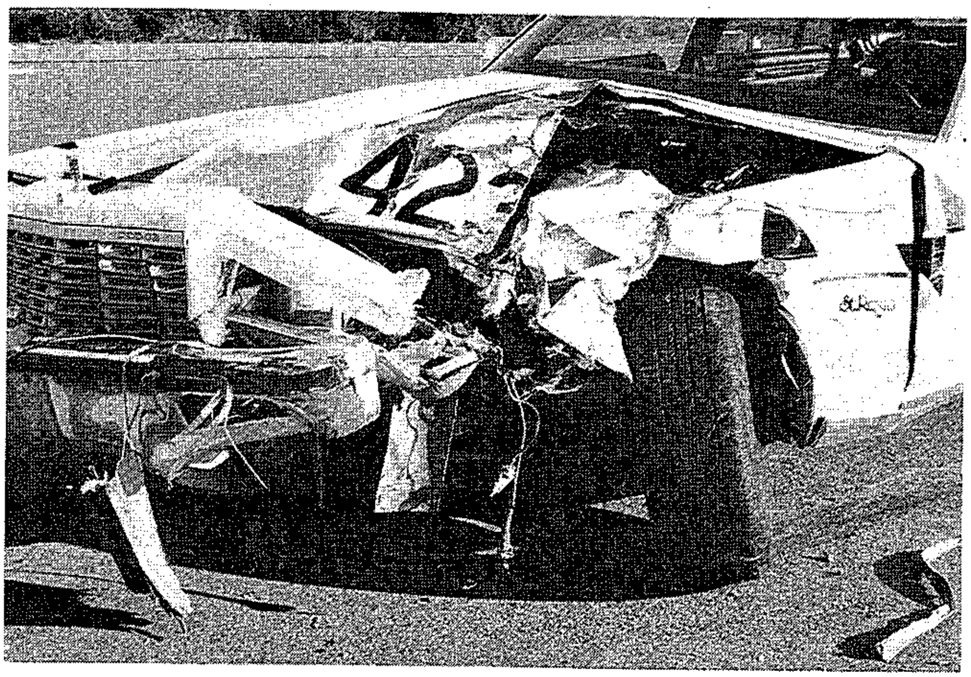
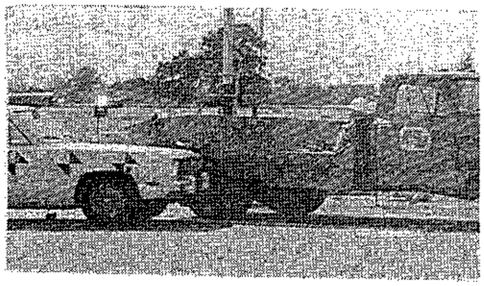
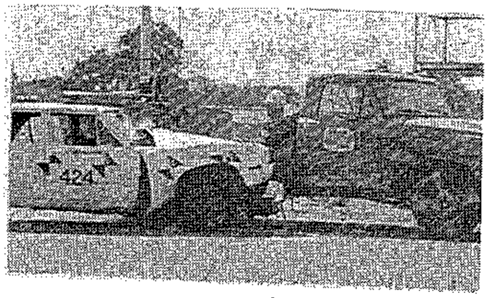


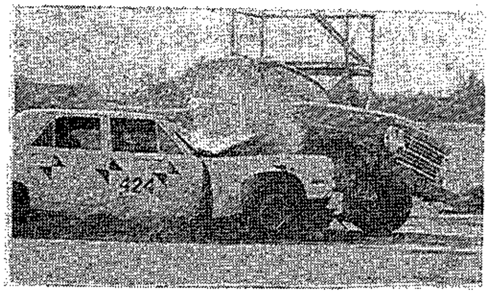
FIGURE 423-4



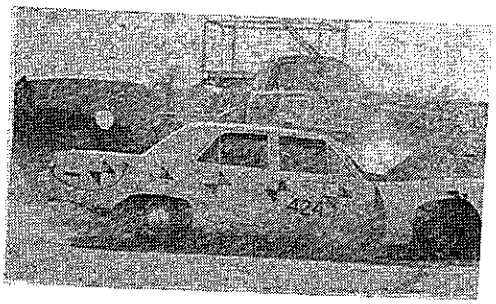
Impact + .010 seconds



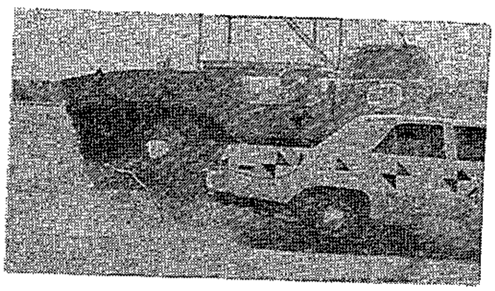
Impact + .085 seconds



Impact + .235 seconds



Impact + .385 seconds



Impact + .535 seconds

DATA SUMMARY SHEET TEST #424
TEST DATE SEPTEMBER 4, 1985

CONE TRUCK DATE

Model	Ford Cab
Gross Vehicle Weight	6200 lbs
Bed Type	Conesetting
Brake Setting	Parking 1/2 engaged
Gear Setting	2nd gear
Side Box Modifications	Yes

DUMMY DATA

Dummy #1, Sierra part #120,
95 Percentile male was seated on the right side of the truck conesetting bed, facing the rear.
Dummy Height - 6' Dummy Weight-221
Dummy Restraint Lap Belt

Dummy #2, Sierra Part #572,
50 Percentile male was seated on the left side of the truck conesetting bed, facing forward.
Dummy Height - 5-9' Dummy Weight-165
Dummy Restraint Lap Belt

VEHICLE DATA

Model	1975 Plymouth Valiant
Impact Velocity	61.8 MPH
Impact Angle	25 degree/right side
Weight without dummy	3660 lbs

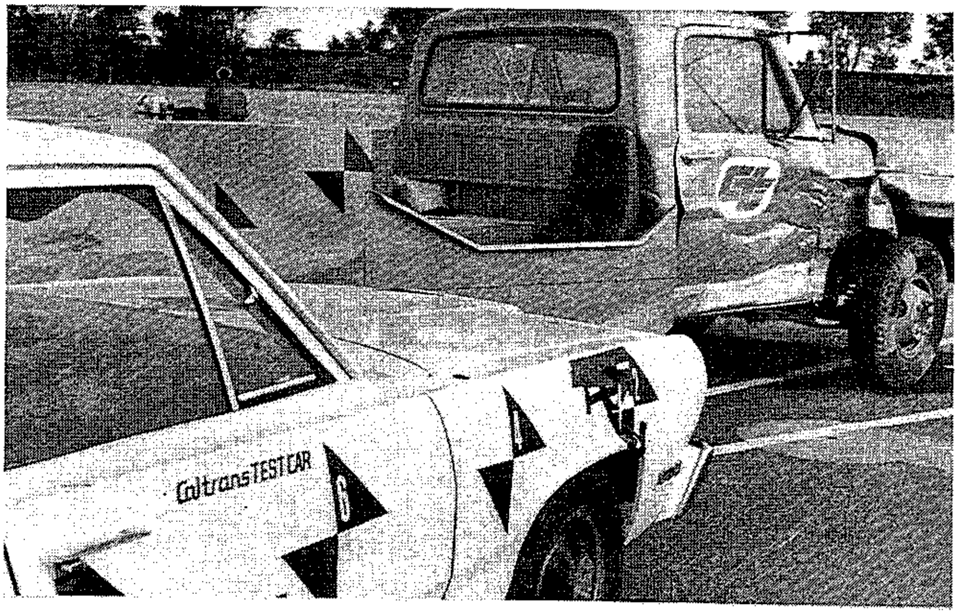
IMPACT DATA

Max. 50 MS Avg. Acceleration

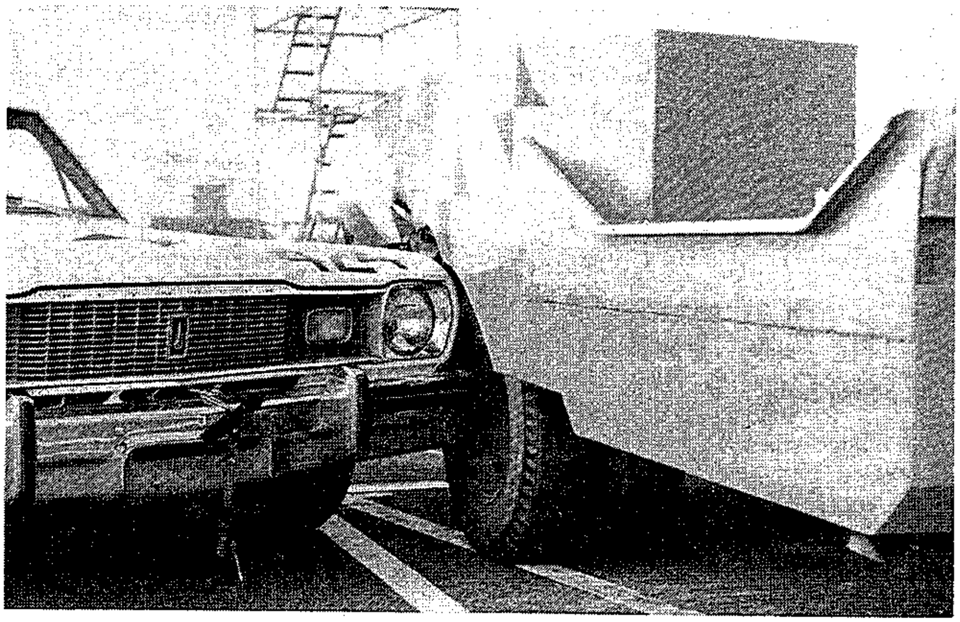
Car, Longitudinal	-11.4 G
Car, Lateral	-5.7 G
Conetruck,Longitudinal	6.3 G
Conetruck,Lateral	7.7 G
Dummy Head Resultant	12.2 G

Truck Roll Ahead Distance-
56.6 feet forward and left 20.9 feet

FIGURE 424-1



TEST 424



TEST VEHICLE
BEFORE IMPACT

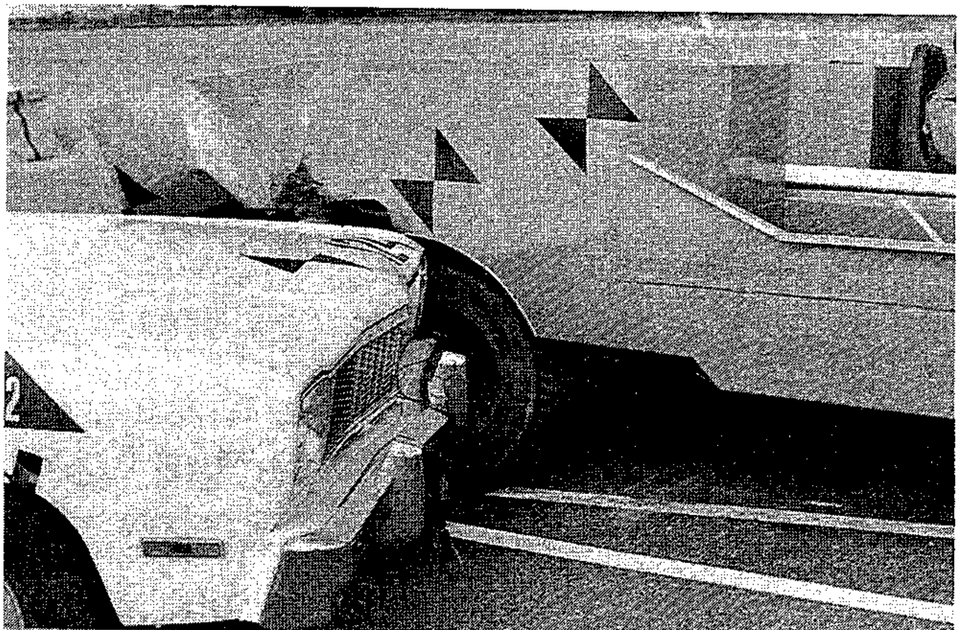
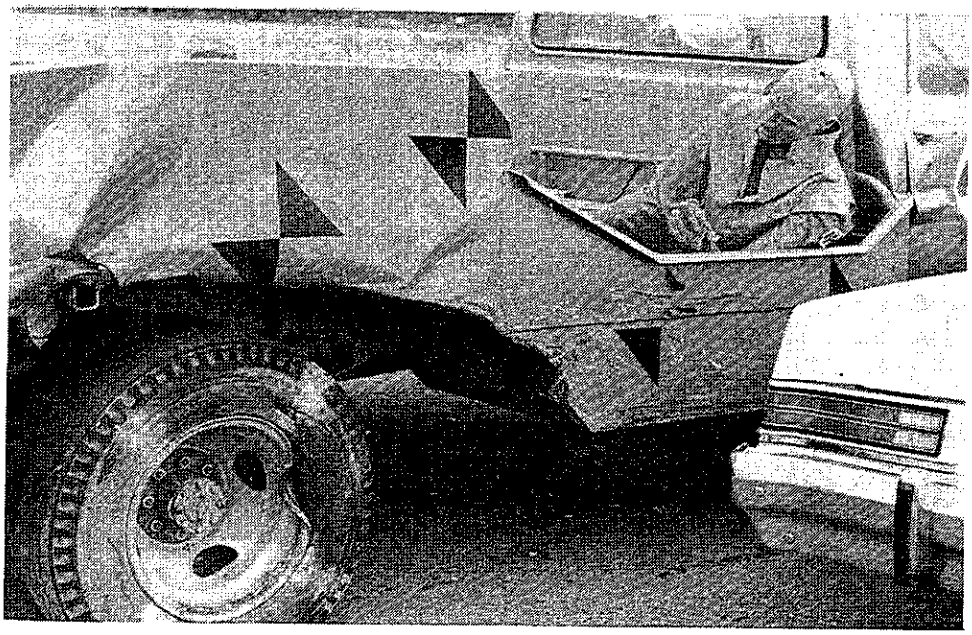


FIGURE 424-2

TEST 424



TEST VEHICLES
AFTER IMPACT

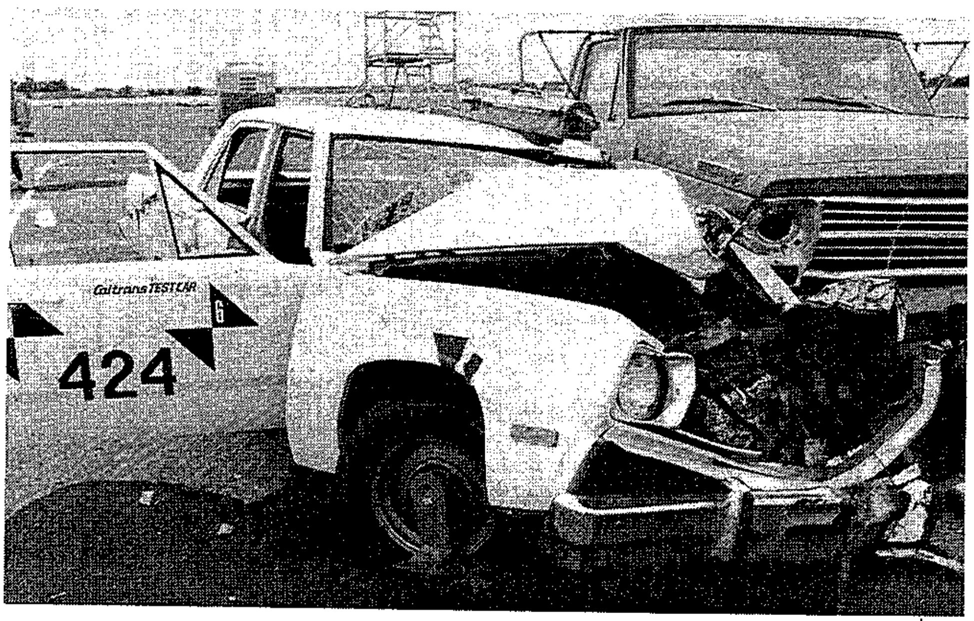
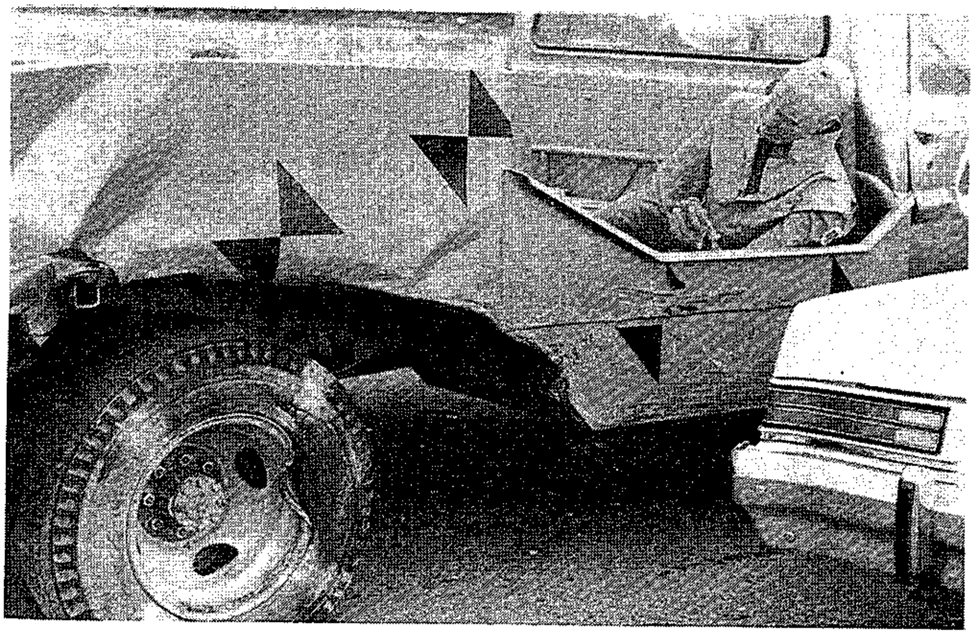


FIGURE 424-3

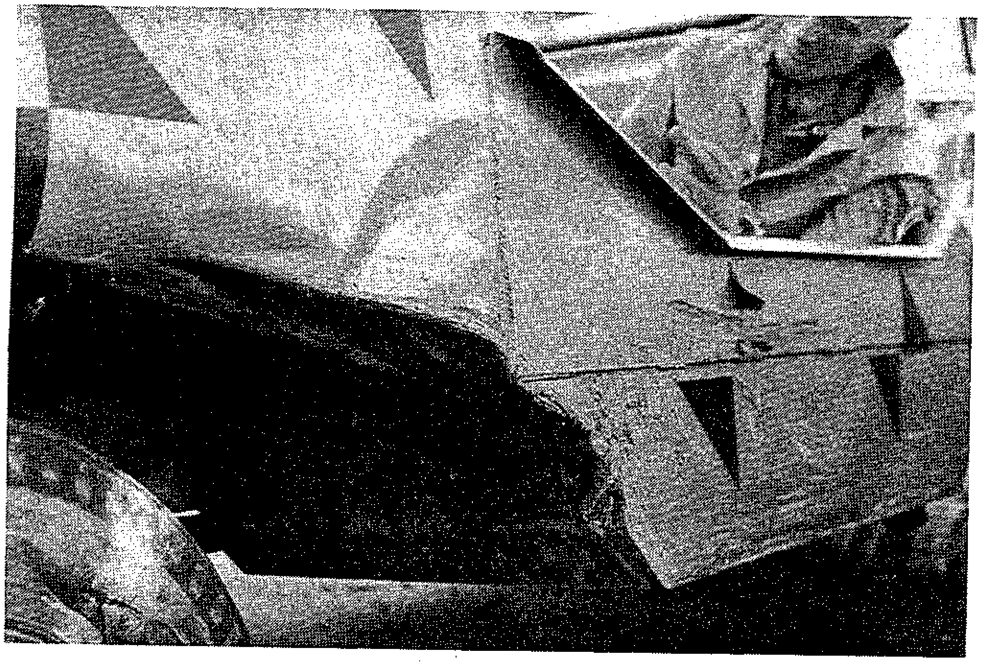
TEST 424



TEST VEHICLES
AFTER IMPACT

FIGURE 424-3

TEST 424



TEST VEHICLES
AFTER IMPACT

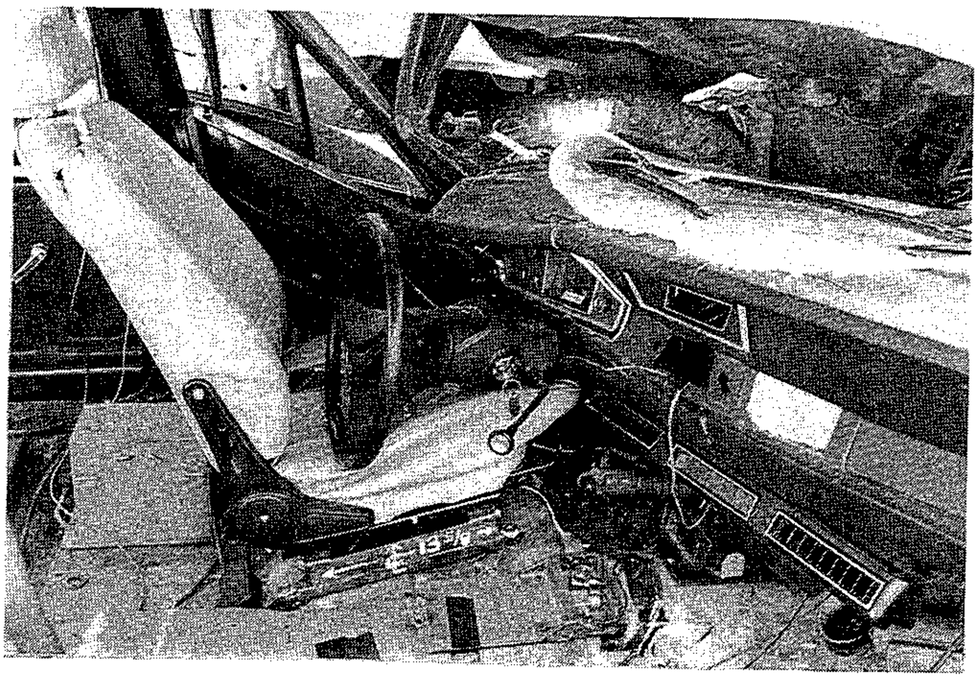


FIGURE 424-4

7. References

1. California Department of Transportation, Office of Business Management, Material Operations Branch, Specification for Fluorescent Plastic Traffic Cones No. 9905-0150-6 and 0170-8.

2. Operational Procedures and Equipment Used in the Placement/Retrieval of Portable Traffic Delineators, A Special Study 4/82, Caltrans.

3. California Department of Transportation, Division of Maintenance, Maintenance Manual of Instructions.

4. Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances, Transportation Research Circular No. 191, February 1978.

5. California Department of Transportation, Division of Equipment Maintenance and Development, Cone Truck Cab and Chassis Specification, Item 01037.

APPENDIX A: TEST VEHICLE EQUIPMENT AND CABLE GUIDANCE SYSTEM

The test vehicles were modified as follows for the crash tests:

Four 12-volt wet cell lead acid motorcycle-type batteries were mounted in the car to supply power for the test equipment. Two supplies power to the high speed camera and lamps located inside the vehicle. The other pair of batteries operated the solenoid-valve braking system and other test equipment installed in the vehicle.

The test vehicle gas tank was disconnected from the fuel supply line and drained. In tests 422,423, and 424, the tank was filled with water to add weight to the car and eliminate the fire hazard. In Test 421 extra weight was not needed, and dry ice was placed in the empty tank to inhibit combustion. A one-gallon safety gas tank was installed in the trunk compartment and connected to the fuel supply line.

The accelerator pedal was linked to a small cylinder with a piston which opened the throttle. The piston was activated by a manually thrown switch mounted on the top rear fender of the test vehicle. The piston was connected to the same CO_2 cartridge used for the braking system, but a separate regulator was used to control the pressure. The car was placed in the drive position on the automatic transmission.

A speed control device which was connected between the negative side of the coil and the battery of the vehicle, regulated the speed of the test vehicle based on speedometer cable output. This device was calibrated prior to the test by conducting a series of trial runs through a speed trap composed of two tape switches set a known distance apart and connected to a digital timer.

A cable guidance system was used to direct the vehicle into the conetruck. The guidance cable, anchored at one end of the vehicle path to a threaded coupler embedded in a concrete footing, passed through a guide bracket bolted to the spindle of the front wheel of the test vehicle on the side away from impact. A steel knockoff bracket, which anchored the opposite end of the cable near the conetruck to a concrete footing, projected high enough to knock off the guide bracket thereby releasing the vehicle from the guidance cable prior to impact.

A microswitch was mounted below the front bumper and connected to the ignition system. A trip plate placed on the ground near the impact point triggered the switch when the car passed over it. This opened the ignition circuit, cut the vehicle engine prior to impact and released the sliding weight mounted on the roof of the vehicle from an electro-magnet so the weight was free to travel immediately before impact.

A solenoid-valve actuated CO^2 system was used for remote braking after impact and for emergency braking at any other time. Part of this system was a cylinder with a piston which was attached to the brake pedal. The pressure used to operate the piston was regulated according to the test vehicle's weight. This allowed the vehicle to stop without locking up the wheels.

The remote brakes were controlled at the console trailer by using an instrumentation cable connected between the vehicle and the electronic instrumentation trailer and a cable from the trailer to the console trailer. Any loss of continuity in these cables caused an automatic activation of the brake and ignition cut off. Remote activation of the brakes also would turn off the ignition.

APPENDIX B: PHOTO-INSTRUMENTATION

Data film was obtained by using five high speed PhotoSonics Model 16mm 1B cameras, 200/400 framer per second (fps), and four high speed Redlake Locam cameras, 400 fps. These cameras were located around the impact area. The cameras were electrically actuated from a central control console located adjacent to the impact area except for three which had their own battery power and were turned on by three separate operators.

All high speed cameras were equipped with timing light generators which exposed reddish timing pips on the film at a rate of 1,000 per second. The pips were used to determine camera frame rates and to establish time/sequence relationships. Data from the high speed movies were reduced on a Vanguard Motion Analyzer. Some procedures used to facilitate data reduction for the test are listed as follows:

1. Butterfly targets were attached to the test car and conetruck, for film data acquistion.

2. Flashbulbs mounted on the test vehicle were electronically flashed to establish (a) initial vehicle/barrier contact (b) application of the vehicle's brakes and (c) beginning and ending of sliding weight travel. The impact flashbulbs have a delay of several milliseconds before lighting up.

3. Five tape switches placed at ten foot intervals were attached to the ground perpendicular to the path of the impacting vehicle beginning about five feet from impact. Flashbulbs were activated sequentially when the tires of the test vehicle rolled over the tape switches. The flashbulb stand was placed in view of most of the data cameras or made visible to the tower cameras through the use of mirrors. The flashing bulbs were used to correlate the cameras with the impact events and to calculate the impact speed independent of the electronic speed trap.

Additional coverage of the impacts were obtained by a 70 mm Hulcher sequence camera and a 35 mm Hulcher sequence camera (both operating at 20 frames per second). Documentary coverage of the tests consisted of normal speed movies and still photographs taken before, during, and after impact.

A sliding weight device was mounted on all test cars to determine the rattlespace time. This device would only be used if accelerometer data failed. The weight contains ball bearings which roll along a smooth rod. The weight is held in place on the left end of the rod by an electromagnet before impact. The front bumper switch on the car which cuts the ignition about two feet before impact also cuts off the current to

the electromagnet. The weight is then free to slide forward for a two foot distance on the rod after impact. The time it takes for the weight to travel two feet (rattlespace time) is determined from the high speed movie film. Flashbulbs mounted on the device are activated when the weight begins to move and also when it reaches the end of its travel. The flashbulbs are more visible to distant data cameras than the sliding weight.

APPENDIX C: ELECTRONIC INSTRUMENTATION AND DATA

Six accelerometers measured acceleration. Three unbonded strain accelerometers (Statham) were at the longitudinal and lateral center of gravity of the cars. One each was oriented in the longitudinal, lateral, and vertical direction. These accelerometers were mounted on a small rectangular steel plate which was welded to the floorboard of the vehicle.

Three Endevco Model 2262-200 piezo-resistive accelerometers were mounted in the head of the dummy seated on the side opposite impact. Those mounted in the car and in the cab of the conetruck were close to the vehicle center of gravity in the horizontal plane. Those in the conetruck bed were mounted on the inside edge of the conesetter's compartment (impact side only) where they received solid support from the truck frame.

Data from the accelerometers in the test vehicle were transmitted through 1,000 foot Beldon #8776 umbilical cable connecting the vehicle to a 14 channel Hewlett Packard 3924C magnetic tape recording system. This recording system was in an instrumentation trailer at the test control area.

Three pressure activated tape switches were placed on the ground in front of the conetruck. They were spaced at carefully measured intervals of 12 feet. When the test vehicle tires passed over them, the switches produced sequential impulses of "event blips" which were recorded concurrently with the accelerometer signals on the tape recorder and served as "event markers". A tape switch on the front bumper of the car closed at the instant of impact and activated flashbulbs mounted on the car. The closure of the bumper switch also put a "blip" or "event marker" on the recording tape. A time cycle was recorded continuously on the tape with a frequency of 500 cycles per second. The impact velocity of the vehicle could be determined from the tape switch impulses and the timing cycles. Two other tape switches, connected to digital readout equipment were placed 12 feet apart just upstream of the cone truck to determine the impact speed of the test vehicle immediately after the test.

All accelerometer data was processed on a Norland Model 3001 waveform analyzer, the primary means of data reduction. The analyzer digitized and manipulated the raw data, printed test results, and plotted various curves.

The occupant impact velocity is theoretical; however, on the plot distance vs time, the curves can be visualized as representing the car windshield and the driver's head. It is assumed that the head starts out two feet behind the windshield. The point where the curves cross represents the impact between the head and the windshield because the windshield was slowed down from the impact velocity, and the head was not. The time when the windshield/head impact occurs (rattlespace time) is carried to the plot of

velocity vs time. The occupant impact velocity is the difference between the vehicle impact velocity and the vehicle velocity at the end of the rattlespace time.

The dummy accelerometers are not used in determining the occupant impact velocity, only the vehicle accelerometers.

Due to technical difficulties there was not accelerometer data for Test 421 (conetruck data and occupant impact velocity) and Test 424 (lateral for test car and conetruck). Data previously used in this report for these tests was film data.